ROCHESTER AREAWIDE

# ADVANCED TRANSPORTATION MANAGEMENT SYSTEM

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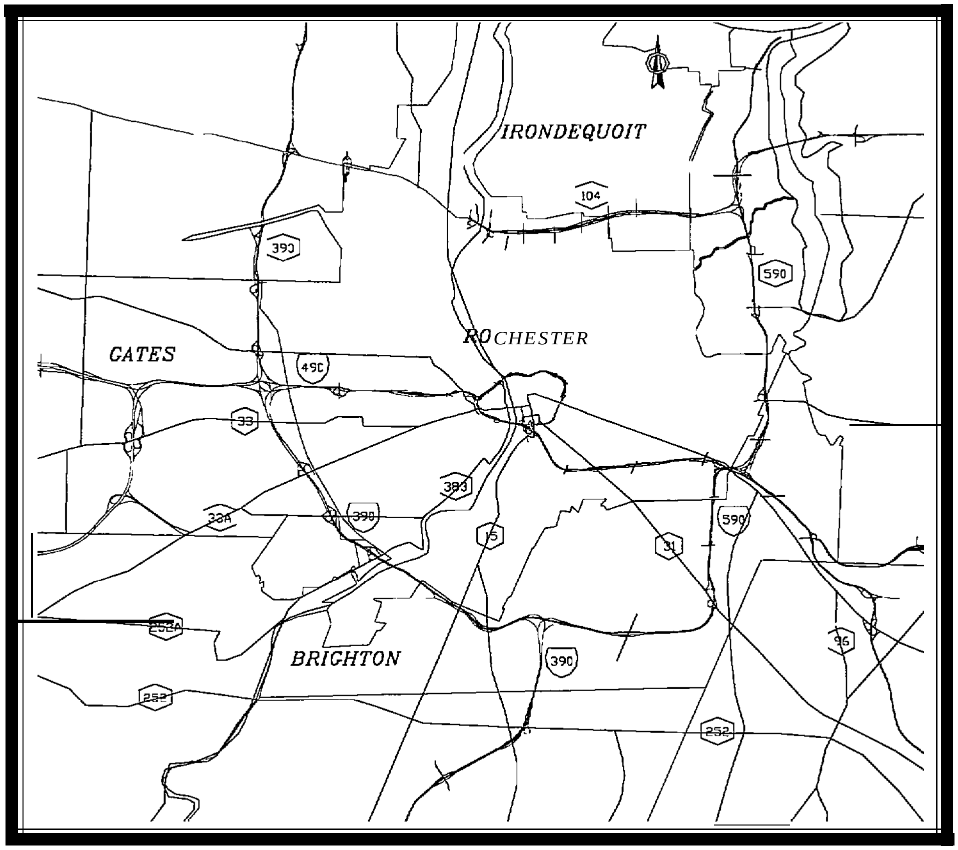



**PREPARED FOR:**

**NEW YORK STATE DEPARTMENT OF TRANSPORTATION**
**REGION 4**

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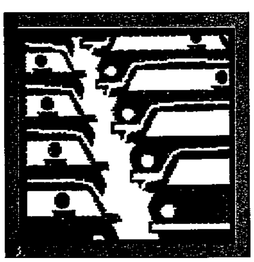

## CHAPTER



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**ROCHESTER AREAWIDE**

**ADVANCE TRANSPORTATION**

**MANAGEMENT SYSTEM**

## Technical Advisory Committee / Incident Management Task Force

- NYSDOT Region 4 Traffic Engineering and Safety
- NYSDOT Region 4 Maintenance
- NYSDOT Main Office - Albany
- FHWA
- Genesee Transportation Council
- NYS Police
- MC Office of Emergency Preparedness
- MC Public Safety
- MC Communications
- MC Emergency Medical Services
- ECBS - (Citizens Band Radio Users Group)
- Rochester Genesee Regional Transportation Authority
- MC Department of Transportation
- MC Sheriffs Department
- Rochester Fire Department
- Rochester Police Department
- City of Rochester Engineering Bureau
- MC **911** Center
- MC Health Department
- ESTRA - (Tow Truck Operators Group)

# EXECUTIVE SUMMARY

## Purpose of the Project

The purpose of this study is to provide the framework to base future designs of Intelligent Transportation Systems (ITS) for the Metropolitan Rochester area. The initial focus of the project was the regional freeway system, over time this has been broadened out to include the transportation network including major arterial routes and the regional transit system. Participation and cooperation by all parties involved such as transportation officials, emergency response personnel, the private sector and universities are essential. This study will ultimately determine the most appropriate initiatives to be implemented in an Advanced Transportation Management System (ATMS).

## Project Location

The Intelligent Transportation Systems Early Deployment Study of the Greater Rochester area focuses on the expressway routes and arterial routes in Monroe County, New York. Figure ES-l highlights the routes of the Study Area for the Advanced Transportation Management System project. Several of the arterial routes within Monroe County are also included in the analysis; however, the primary emphasis is on the expressway system.

## Initial Goals, Objectives and Measures of Effectiveness

The goal of the ATMS is to manage the transportation system to reduce traffic congestion and to improve the efficiency of the incident management process through the integrated management of the freeway and arterial roadway network together with providing information to help effectively manage the regional transit system.

As a result of this goal, certain regional objectives will also likely be defined as a part of an overall evaluation process. These include:

- Reduced fuel consumption
- Reduced user delay
- Improved safety
- Improved communications between transportation providers

Other Benefits of Intelligent Transportation Systems (ITS) are outlined in a report prepared by The MITRE Corporation entitled “Intelligent Transportation Infrastructure Benefits: Expected and Experienced”. This report was prepared for the Federal Highway Administration, and published in January, 1996. The use of ITS has demonstrated positive effects on several measurable Measures of Effectiveness (MOEs) including the following:

Expressway Traffic Management Systems

Decreases in travel times of 20% to 48%
Increases in travel speeds of 16% to 62%
Increases in freeway capacity of 17% to 25%
Decreases in accident rates of 15% to 50%
Decreases in fuel consumption during congestion of 41%
Annual decreases in emissions of 122,000 tons of carbon monoxide (CO)
Annual decreases in emissions of 1400 tons of hydro carbons (HC)
Annual decreases in emissions of 1200 tons of nitrous oxide (NOx)

Arterial Traffic Signal Systems

Increases in travel speeds of 14% to 22%
Reductions in travel times of 8% to 15%
Reduction of vehicle stops by 0% to 35%
Reduction in delays of 17% to 37%
Reductions in fuel consumption of 6% to 12%
Annual decreases in automobile emissions of 5% to 13% of the CO
Annual decreases in emissions of 4% to 10% of the HC

Incident Management Programs

Reduced incident clearance times of approximately 8 minutes for stalled vehicles
Reduced incident clearance times of approximately 5 to 7 minute for removing vehicles with a wrecker

Travel times also increase with the reduction in time it takes to remove vehicles from the travel lanes. These decreases in travel times average 10% to 42%. In urban areas, the decrease in the number of fatal accidents is approximately 10%. The reduction in secondary incidents due to incident management programs is difficult to estimate.

Traveler Information Systems

Reduction in travel times of 20% during incident conditions
Decrease of 1900 vehicle-hours of delay per incident
Decrease of 6% to 12% in fuel consumption
Decrease of fuel emissions from the affected vehicles of volatile organic compounds (VOC) by 25%
Reduction in HC by 33%
Decrease in NOx by 1.5%

Recommended strategies will likely be integrated with the existing computerized traffic signal system. Short-Term, Medium-Term and Long-Term deployment plans have been recommended (see Figure ES-2). The Short-Term is defined as 2 to 3 years from now, Medium-Term as approximately 5 years and Long-Term could be defined as 10 to 20 years. Early deployment plans or Near-Term is defined as something that could be implemented within 1 year. The non-technical barriers and constraints to implementing the ATMS have also been evaluated.

**Existing ITS Initiatives**

Monroe County Department of Transportation operates the Urban Traffic Control System (UTCS) and Zone Monitor system comprised of approximately 360 traffic signals within the County. Upgrading and integrating the UTCS with the proposed Advanced Transportation Management System (ATMS) is one key issue to the success of the areawide system. The New York State Department of Transportation operates two Roadway/Weather Information System (RWIS) sites on Route 104 on the Irondequoit Bay Bridge and two miles east of the bridge in Region 4. The information gathered by the sensors is used to dispatch sand and salt for anti-icing rather than de-icing. The Communications Division of the Monroe County Department of Public Safety is responsible for all emergency services communications. They own, operate and maintain the microwave system which will be upgraded to a 632 channel digital system. NYSDOT Telephone System utilizes a Wide Area Network (WAN) called the Empire Net to connect the Regions with Albany. The Empire Net is comprised of IBM, NYNEX and Eastern Microwave. The Monroe County Office of Emergency Preparedness responsibilities include contingency planning for emergencies. They operate a mobile communications trailer that is used for field situations. The New York State Thruway Authority has a system of toll collection called EZPass. The system has not yet reached the Rochester area. Associated with the EZPass system is the TRANSMIT project, which utilizes the EZPass transponders to track traffic and detect areas of congestion along the NYS Thruway.

**Traffic Congestion**

Traffic and accident data were gathered from various sources and summarized for the expressways and many of the major arterial routes within Monroe County. The areas that experience recurring congestion due to traffic volumes and nonrecurring congestion due to incidents as well as traffic volumes were determined through an evaluation criteria. These areas were the focus of the ATMS Early Deployment Plan. The New York State Department of Transportation (NYSDOT) Region 4, Traffic Engineering and Planning Department ‘provided traffic and accident data for these expressway routes and the majority of the state arterial route system in Monroe County.

Of the approximately 100 miles of primary routes that were evaluated approximately 33 miles experience recurring congestion or volume related congestion (see Figure ES-3), while approximately 25 miles of roadway experience nonrecurring or incident related congestion (see Figure ES-4). In the future year 2015, approximately 50 miles of the primary roadways in the study area will experience recurring congestion (see Figure ES-5). Based upon the anticipated traffic volume growth in the area it is predicted that the nonrecurring congestion will cover at least the same amount of roadway miles in the year 2015. The secondary arterial routes that were studied for this project total 97 miles. Of these 97 miles of arterial routes, 21 miles experience recurring congestion and 24 miles experience nonrecurring congestion. In the future year 2015, approximately 31 miles of arterial routes will experience recurring congestion.

**Institutional Issues**

Various agencies within the Rochester area were interviewed to gain an understanding of their goals, roles and responsibilities with respect to Intelligent Transportation System deployment. The initial agencies interviewed included the following:

New York State Department of Transportation
Monroe County Department of Transportation
City of Rochester Engineering Bureau
Regional Transit Authority
Genesee Transportation Council
New York State Thruway Authority
Monroe County's "911" network
Office of Emergency Preparedness

Other agencies were interviewed and the total interview summaries can be found in Appendix B. The overall user services that should be satisfied with the ATMS include enroute driver guidance, route guidance, incident management and traveler services information. Also included in the survey results was a need for emergency vehicle management, public transportation management and enroute transit information. A summary of the issues and concerns as they relate to institutional issues, political concerns, project selection and development, evaluation, funding, procurement, maintenance, centralization versus decentralization, operations and information centers, integration and coordination as well as standards can be found in Chapter II, Existing and Future Conditions / Institutional Issues / User Needs.

**Vision Statement**

The stakeholders, along with the consultants, developed a vision statement to define the future as it relate to deployment of ITS. Chapter III, A Long-Term Vision Statement, outlines the five (5) goals which include providing for a cost effective ATMS, an advanced traveler information system (ATIS) with wide coverage, improved emergency response, promote public/private partnerships and promote feedback and continual evaluation of the performance of the systems. The informational and technical needs of the agencies involved are summarized in the Vision as well as the benefits received by the various customers in the Rochester area. The roles and responsibilities of the relevant agencies are also outlined in the Vision. Maintenance and operations agreements are issues that begin to be developed in the Vision.

**Strategies Evaluation**

Chapter IV is an extensive summary of the potential improvement options for transportation management. This section describes the potential measures for detection and verification, reduction in response times, site management, clearance times and traveler information. Some of the options are low-tech manual strategies that provide a relatively high benefit for a relatively low cost to operate and maintain. They would include the following:

- Incident Reporting with Cellular Phones
- Personnel, Equipment and Materials Resource Lists
- Tow Truck/Removal Crane Contracts
- Equipment Storage Sites
- Closely Spaced Reference Markers
- Push Bumpers on Emergency Response Vehicles
- Total Station Accident Investigation Equipment
- Roadway Weather Information System Expansion

Other strategies are more expensive high-tech electronic techniques that provide for more accurate and timely detection and verification of incidents. Some of the strategies are already in place and just need to be improved and/or formalized through agreements with the participating agencies. Selected recommendations are included at the end of the section with relative time frames for implementation. The NYSDOT's roadway/weather information system is described in Chapter IV. Appendix D, Functional Assessment of Technologies, is an excellent summary and reference document that focuses on the technologies used for traffic surveillance, closed circuit television cameras as well as the communications associated with them, electronic toll and traffic management systems, variable message signs, highway advisory radio transmitters, kiosks and dial-in telephone systems. A comprehensive comparison of different traffic control architectures that are currently available is also summarized in Appendix D.

**Regional Communication and Architecture**

Chapter V, Regional Communications and Architecture, describes the communications requirements of the components of an ATMS. Various technologies and types of communications options are included in the text. The communications protocols for variable message signs, ramp metering signals, electronic toll and traffic management devices, highway advisory radio transmitters, roadway weather information system sensors, CCTV cameras are mentioned in this chapter. The existing communications infrastructure within Monroe County is summarized in Figures V-l, V-2 and V-3. Various types of communications methods are explained in the text, such as cellular phones, T-l lines, twisted pair wire, coaxial cable and fiber optic cable. Tables V-2 and V-3 summarize various costs for communication system implementation. Partnership opportunities are explored in the later sections of this chapter. In general, specific recommendations should be delayed until it is found what type of public/private partnership can be structured. The communications necessary for the ATMS can then be built into what becomes available, with owned infrastructure required only for the features that are not provided through the partnership.

**Monroe County UTCS**

In order to interface with any kind of future automated Traffic Operations Center, the existing computer system running the Monroe County UTCS traffic signal system will need to be upgraded or replaced. Chapter VI describes the options that the Monroe County Department of Transportation has for upgrading the Urban Traffic Control System. The cost of these options are summarized in the table at the end of the text. Some of the options included in the report are traffic signal timing and phasing changes, including a remote access into the system, traffic responsive operations and controller upgrades. Some of the higher level changes require central hardware and software replacement. Costs associated with the changes and upgrades to the UTCS and Zone Monitoring systems are summarized in Table VI-l

**Strategic Implementation / Deployment Plan**

The plan provides the recommendations to go forward in the deployment of the ATMS equipment. Based upon the benefit cost ratios developed from the traffic and accident data from NYSDOT, the corridors were designated from highest to lowest benefit cost. CCTV cameras, VMS and traffic flow detection equipment will be placed in these corridors based upon the proposed time frame. Roadway weather information system elements, the traffic operations center, traffic signal control and traveler information center are proposed for the ATMS along with privately funded expressway service patrols.

A guide has been developed for the placement of the ATMS equipment. The guide provides rule-of-thumb directions for the placement of variable message signs, CCTV cameras, traffic flow detection equipment, and for the determination of alternative routes. The main point is to inform motorists of congestion, provide information about the incident and information on alternative routes. Figure ES-2 illustrates the implementation corridor coverage.

The recommendations for the expressways are listed in the Strategic Implementation/Deployment Plan. The Near-Term Implementation Plan includes variable message signs and closed circuit television cameras, as well as roadway reference markers, "911 Call-In" signs, two total stations for accident investigation and allocation for equipment in a temporary TOC. The total capital cost for this phase of implementation is approximately $2.2 million. The Short-Term Implementation Plan of the Strategic Implementation/Deployment Plan describes the development of the first four (4) expressway segments with the highest benefit cost ratios. The approximate total capital expenditure for the equipment listed in Table VII-3 for the Short-Term is approximately $12.4 million. The Short-Term phase should also include the additional cost of developing a permanent Traffic Operations Center and the related software development for the control of the various systems (CCTV, VMS, traffic flow/detection, HAR, etc.). This would total approximately $3.5 million, and could be lower depending upon the magnitude of the TOC development. The second phase or the Medium-Term, 5 to 10 year plan is to complete the next four (4) expressway segments with the next highest benefit cost ratios. The total capital cost for the equipment described in Table VII-3 for the Medium-Term is approximately $11.6 million. The remaining Long-Term Implementation Segments of the expressway segments in the study area could be completed at a later date at a total capital cost of $8.8 million. The single highest cost is the communications system consisting of fiber optic conduit and cable, and related hardware. This amounts to nearly $20 million for all phases of implementation.

Table ES- 1
Capital Cost Summary
Fully Instrumented System

| Phase | Primary Routes | Secondary Routes | Total |
|---|---|---|---|
| Near-Term | $ 2.2 million | $0.7 million | $ 2.9 million |
| Short-Term | $12.4 million | $4.1 million | $16.5 million |
| Medium Term | $11.6 million | $8.2 million | $19.8 million |
| Long-Term | $ 8.8 million | $5.4 million | $14.2 million |

Control of the traffic signals along the parallel arterial routes should be incorporated into the design of the Short, Medium and Long-Term implementations. As in the recommendation of the Near-Term deployment, the traffic signals along East Ridge Road will be incorporated with the Route 104 (Reeler Expressway) initial expressway management system. The traffic signals along East Ridge Road will have appropriate timing plans developed to allow diverted traffic to be processed through each intersection. In other instances Route 104 will be used as an alternative to East Ridge Road. In the Short, Medium and Long-Term recommendations the remaining traffic signals, not currently on a system, should be expanded to include arterial routes parallel to expressway segments.

The secondary arterial routes are instrumented in a slightly different manor. Changeable message signs (CMS) are recommended over variable message signs (VMS). CMS are less obtrusive than VMS. VMS are generally brighter and larger than CMS. CMS are usually limited in the amount of information that can be displayed. At key interchanges of high volume arterial routes, it may be warranted to install VMS to provide more information to the motorist. During the design stages of this project, a benefit cost comparison would be needed, based upon the number of vehicles that pass the particular sign location and the amount of information that is needed to transmit to the motoring public. For example, a relatively low volume arterial route that feeds the expressway would only need a CMS to inform travelers on which route to continue. But a high volume arterial route that feeds the expressway may need a full VMS to display the necessary information

The cost calculations tables, for the expressways and arterial routes (Tables VII-3 and VII-S), list the equipment that is proposed to be implemented along each roadway segment. The Intelligent Transportation System (ITS) equipment is tabulated along with their total annualized cost. These annualized costs are used to calculate the benefit cost ratios. It was determined that Service Patrols would be pursued as a partnership with the private sector. The private sponsor would cover the majority of the cost of the patrol.

Explanation of the benefit cost ratios and how they were developed are provided in Chapter VII. Tables VII-2 through VII-7 provide summaries of the annualized benefits and the annualized capitol costs for the deployment of the phases of the ATMS for the primary expressways and major arterial routes within the county.

Table ES-2
Annual Benefit/Cost Summary
Fully Instrumented System

| Phase | Primary Routes | Secondary Routes |
|---|---|---|
| *Near-Term | 2.62 | 2.43 |
| Short-Term | 3.10 | 3.19 |
| Medium Term | 1.59 | 1.48 |
| Long-Term | 0.29 | 3.14 |

* Near-Term - Not Fully Instrumented

In Table VII-2, the benefit/cost ratio for the Near-Term phase includes the costs associated with a fully instrumented system for the Keeler Expressway. In Tables VII-3 and VII-4, the Near-Term phase of the implementation includes some costs for highway advisory radio transmitters, communications, roadway markers and other costs that are associated with the beginning of the fully instrumented ATMS. In addition to these costs, the costs associated with the Roadway/Weather Information System equipment, are also included in the Near-Term. The benefit/cost ratios for the RWIS can be calculated separately on the basis of an areawide system. The revised benefit/cost ratio for the Near-Term phase is calculated to be 2.62. This benefit/cost ratio includes the cost of the equipment associated with the Near-Term Keeler Expressway corridor between the Genesee River and Route 590 and takes into account the fact that the system is not fully instrumented by using 75 percent of the total benefit. The Near-Term expenditure includes four (4) variable message signs for the Keeler Expressway/Route 104 corridor, a highway advisory radio system to cover the entire ATMS area, four (4) CCTV cameras (two for the Keeler Expressway, one for the Troop-Howell Bridge and one for the Can 0' Worms), two (2) total stations which would be used for the entire Monroe County area, reference/milepost markers for 100 miles of expressway in the County and nine (9) RWIS sites throughout the County. The benefits associated with these costs are not easily quantifiable to accurately determine the benefit/cost ratios for the entire Near-Term expenditure. However, as mentioned previously in *Initial Goals, Objectives and Measures of Effectiveness,* Traveler Information does account for large reductions in travel time, delay and emissions over a large geographic area. Therefore, it is safe to say that the benefit/cost ratio for the Near-Term implementation is close to 3 : 1.

**Traffic Operation Center Evaluation**

A list of twenty-four potential traffic operation center (TOC) sites was assembled by the participants in the ATMS study (see Table VIII-4). These potential TOC sites were evaluated on the basis of such criteria as location, space, ownership, highway access, costs, communications links, utilities and site security. The two phase evaluation ranks the top 10 locations with a weighted score based on 1,000 points. The results of the phase two evaluation can be found in Table VIII-5.

**Operations Plan**

Chapter IX presents a review of actions and issues related to the operations and implementation of the future system. Procurement methods, staffing, TOC sizing, system start-up plan requirements, and operations plan requirements are addressed. The Potential need for cooperative Agreements or Memorandums of Understanding would likely include the following four categories:

- Agency Support
- System Construction, Operations and Maintenance
- Emergency Response
- Specialized Control Plans

The hours of operation are discussed as well as the duties of the operators. These duties include monitoring and controlling the CCTV cameras, changing the messages on the VMS, responding to alarms from the traffic flow detection equipment, communicating with the other involved agencies in the area and maintaining logs of activities. This chapter also discusses the procurement, maintenance and system management. The concept of the traffic operation center is elaborated upon.

Adequate performance of the equipment tasks for routine, daily operations will generally require personnel in administrative, operations, and maintenance classifications. Of paramount importance in considering overall staff requirements, is the obtainment of a certain level of redundancy in personnel in the operations and maintenance classifications to insure that the random occurrence of simultaneous, multiple events and/or incidents will not adversely affect overall system performance and personnel response.

The staff requirements and costs to achieve this goal are presented as a general basis of defining overall space needs. Daily weekday operations consisting of approximately 15 to

16 hours per day. Approximate hours of operation are anticipated to be 5:30 AM to 8:30 PM to provide adequate coverage for both AM and PM peaks, with allowances for "late clearing" of PM congestion and some overlap of shifts.

The annual operations, maintenance and equipment parts/physical plant in the following table represents the total annual costs at the end of each of the phases. For example, the costs of Operations Staff at the Short-Term phase also includes the cost of Operations Staff of the Near-Term. The costs of Operations Staff at the Medium-Term phase includes the Near, Short and Medium-Term Operation Staff costs.

Table ES-3
Annual O & M Cost Summary
Primary Route System

| Phase | Operations Staff | Maintenance Staff | Equipment Parts/ Physical Plant | Total Annual O&M |
|---|---|---|---|---|
| Near-Term | $60,000 | $50,000 | $40,000 | $150,000 |
| Short-Term | $305,000 | $109,000 | $523,000 | $1,018,000 |
| Medium-Term | $305,000 | $190,000 | $1,103,000 | $1,598,000 |
| Long-Term | $475,000 | $365,000 | $1,198,000 | $2,038,000 |

The annual operations and maintenance (O & M) costs are based upon national averages of 7% per year of initial capital costs. This figure was derived from a survey of approximately ten (10) advanced traffic management systems throughout the country. The Near-Term 0 & M cost will be 5%, slightly less than the 7% average, due to the assumption that during the initial stages the new equipment will be operated by existing staff. Also, any major repairs during the first year should be covered by warrantees and any minor preventative maintenance activities could be handled by existing NYSDOT maintenance staff. The Short-Term 0 & M costs will be in the 7% range. The Medium-Term and Long-Term 0 & M costs will also drop to 5% in the future. This is due to economies of having more spare parts and more experience with the equipment. The estimated operations and maintenance costs for the secondary routes will be in the 2% range. This is due to the fact that there is less new equipment on the secondary routes, less cameras and message signs, than on the primary routes. The traffic signal controllers are presently being maintained by the appropriate agency.

**Partnership Opportunities**

Various members of the private sector were contacted for possible involvement in the ATMS. Private operations, public/private activities and publicly-led activities are among the possibilities. Chapter X, Public/Private Partnership Opportunities, documents the progress of these efforts to involve the private sector in the Greater Rochester ATMS. This is an evolving process that will continue long after this final report is completed. The idea is to keep the private sector involved in research and development of the equipment, as well as the system. The chapter contains summaries of the work to date. Appendix C contains the correspondence that documents the progress of this work effort.

# CHAPTER I

# INVENTORY OF CURRENT REGIONAL ITS ACTIVITIES, GQALS, ROLES AND RESPONSIBILITIES

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# I. INVENTORY OF CURRENT REGIONAL ITS ACTIVITIES, GOALS, ROLES AND RESPONSIBILITIES

## A. Purpose of the Project

The purpose of this study is to provide the framework to base future designs of Intelligent Transportation Systems (ITS) for the Metropolitan Rochester area. The initial focus of the project was the regional freeway system over time this has been broadened out to include the transportation network including major arterials and the regional transit system. Participation and cooperation by all parties involved such as transportation officials, emergency response personnel, the private sector and universities are essential. This study will ultimately determine the most appropriate initiatives to be implemented in an Advanced Transportation Management System (ATMS).

## B. Project Location

The Intelligent Transportation Systems Early Deployment Study of the Greater Rochester area focuses on the expressway routes and arterial routes in Monroe County, New York. Figure I-l highlights the routes of the Primary Study Area for the Advanced Transportation Management System project. Several of the arterial routes within Monroe County are also included in the analysis; however, the primary emphasis is on the expressway system.

## C. Initial Goals, Objectives and Measures of Effectiveness

The goal of the ATMS is to manage the transportation system, to reduce traffic congestion and to improve the efficiency of the incident management process through the integrated management of the freeway and arterial roadway network together with providing information to help effectively manage the regional transit system.

As a result of this goal, certain regional objectives will also likely be defined as a part of an overall evaluation process. These include:

- Reduced fuel consumption
- Reduced user delay
- Improved safety
- Improved communications between transportation providers

In order to evaluate the potential success of any recommendations measures of effectiveness (MOE) can be used to define the success or failure of a strategy or system component. These MOE's are related to the goals and objectives of the project. For the Rochester ATMS project it is suggested that the following MOE's be used in the evaluation process:

- Average vehicle speeds
- Average duration of congestion

- Average delay
- Response and Clearance Time
- Accident numbers
- Diversion impacts

Recommended strategies will likely be integrated with the existing computerized traffic signal system. Short-Term, Medium-Term and Long-Term deployment plans will be recommended. The "Short-Term" is defined as 2 to 5 years from now, "Medium-Term" as approximately 5 to 10 years and "Long-Term" could be defined as more than 10 years. Early deployment plans or "Near-Term" is defined as something that could be implemented within 2 years. The non-technical barriers and constraints to implementing the ATMS will also be evaluated.

## D. Agencies'/Committees' Roles and Responsibilities

There are a number of key agencies and committees in the Greater Rochester area that will be involved to some extent with the proposed ATMS. The following is a brief description of the areas' agencies and their respective roles.

Mr. Lewis Gurley is the Regional Director of the New York State Department of Transportation, Region 4. NYSDOT serves the motoring public, commuters, the trucking industry, transit users, local municipalities and emergency services providers. They are responsible for the operation and maintenance of the state roadways within the region. The Department is also using a Roadway Weather Information System (RWIS) which provides weather and pavement temperature prediction for the regional maintenance deployment of anti-icing techniques. Mr. Peter White, the Regional Highway Maintenance Engineer, oversees the RWIS program.

The Monroe County Department of Transportation (MCDOT) serves motorists by responding to incidents, and assists industrial customers who rely on the system for goods movement. MCDOT serves as the city's traffic engineers, responsible for all traffic control within the city, including the establishment and maintenance of all signs, pavement markers and traffic signals. The City's traffic signals and some of NYSDOT's traffic signals are on the County's UTCS and Zone Monitor arterial management system. The director of MCDOT is Mr. Frank Dolan. Mr. Dolan advises the County Executive and legislature on transportation issues and provides operating assistance to transit.

The City of Rochester's transportation issues are handled through the Department of Environmental Services, Bureau of Engineering Services. Mr. John Thomas is the Transportation Specialist. The Bureau provides services to city residents, commuters, the trucking industry, neighborhoods, businesses, emergency services and the media. They are also involved with incident management.

Mr. William Evans is the Director of Evaluation and Development for the Rochester-Genesee Regional Transportation Authority. RGRTA is active in five of the eight counties in the area. In Monroe County, they provide fixed route service **21** hours a day, totaling 55,000 trips a day, primarily radial to and from the downtown central business district.

Mr. Leonard DePrima is the Division Director of the New York State Thruway Authority. The Division Office is responsible for the operation and maintenance of the Thruway in this region. The Thruway Authority is in the process of installing the E-Z Pass system for toll collections and a Highway Advisory Radio (HAR) system.

Monroe County's "911" network is part of the Department of Public Safety. The Department of Public Safety deals with 80 public agencies, including the Monroe County Department of Transportation. There are administrators for police, EMS and fire who report to the Director of Public Safety. The Department dispatches police, EMS and fire departments to the incidents.

The Communications Division of the Department of Public Safety is responsible for the communication systems of all the emergency services. The Department is currently in the process of changing from a voice system to Mobile Data Terminals in the police vehicles. Ms. Elaine Tette is the Central Police Services Administrator. Mr. Joseph Doyle is the Superintendent of the Communications Division.

The Office of Emergency Preparedness (OEP) is the functional control room for emergency response to any incident at the nearby nuclear power facility and other emergencies. OEP provides emergency and contingency planning for Monroe County. There are 25 public and private agencies involved in emergency responses for man-made, natural and technological disasters. OEP is integrated into the 911 protocol and functions as an alternate site for the county government during emergencies. Ms. Mary Louise Meisenzahl is the Administrator of the Office of Emergency Preparedness.

In addition to these agencies, there are two committees that were formed to address specific issues. The Expressway Committee, composed of transportation officials, business representatives, government officials, the police and public safety officials, was organized to deal with the problems of the local expressways.

The Traffic Control Board serves as an intergovernmental decision-making body which approves all traffic regulations, including the placement of all regulatory signs and traffic signals within the City of Rochester.

## E. Existing ITS Initiatives Evaluations

The following sections describe the Intelligent Transportation System initiatives throughout the region. Much of this information has been gathered through interviews with the parties participating in these initiatives and some information has been summarized from historical information already gathered by team members. To the best of the team's knowledge, the information is the most recent and up to date that team members and interviewees have provided.

## 1. Monroe County Urban Traffic Control System (UTCS)/Zone Monitor

Monroe County operates a UTCS and a Zone Monitor system of traffic signals. The existing UTCS was evaluated based upon site visits with Monroe County. Overall, it was determined to be fully operational and well maintained. In fact, it is one of only three coaxial based UTCS systems that are still in operation in the U.S. today. Like most of the UTCS systems installed in the 1980s it is based on a large Concurrent 3220 processor with a custom central communications unit, but uniquely enough, the system is fully functional and is operating as it was designed. The system was initially installed in 1984 and accepted in 1985. The system currently controls 368 intersections and 500 system detectors.

The Zone Monitor system is a closed loop system which communicates between the control center and several remote traffic signals. The system, which is PC based, currently operates two networks of 5 traffic signals each.

### Work Area

The existing UTCS is located in a spacious room and is designed to accommodate three to six operators. The control center is designed with a three section, gull-wing operators console. Considering the amount of work area that is necessary to maintain a system, any more than three or four operators would cause constant space conflicts. Two additional desks have been placed in the control room to add private workspace. The center section of the console houses the push-button control panel and each wing accommodates an interactive terminal. The end of the right wing has the control workstation and printer for control of an Econolite Closed Loop System that operates independently of the UTCS traffic control system.

The room has a raised computer flooring with forced air temperature control. The air conditioning system is the original system installed in 1980 and provides dual purpose heating and cooling. The system has no external air source. The facility operates on normal power without power suppression or any type of UPS. The County does have a fully functional and maintained diesel power generator for a backup.

### Central Computer System

A large portion of the control room is dedicated to the central computer equipment. It consists of two identical Concurrent 3220 processors and a variety of associated peripheral equipment, such as disks and tapes, connected through bus switches. The two computer systems are arranged in a Master/Slave configuration. The master watches over the slave computer and monitors for "ALIVE" messages. If the slave does stop responding, the master computer takes control of the system and switches the peripherals over to itself for continued operation of the traffic system.

The Concurrent 3220 is based on 1970s 32 bit Mini-computer technology and is currently a limiting factor on the expansion of the system. The system is limited on its memory expansion, available I/O slots and supported peripherals. During the when the UTCS was being developed by FHWA, this machine was one of the fastest on the market and has an "install base" of hundreds of traffic signal systems. In today's standards, it has less raw computer power than that of a normal 486 personal computer. It was designed to perform real time event processing and therefore was a good candidate for the implementation of a traffic signal system. In recent years, it has been proven that this hardware platform is both expensive to maintain and limiting to expansion. The Concurrent 3220 minicomputer has the following configuration:

- Concurrent 3220 processor, 56 inch CPU cabinet, power supplies
- 2MB memory
- Hardware Floating Point
- Two Selector Channels
- Four RSD 80 MB MSM removable disk drives
- 1600bpi 9 track tape system with 56 inch cabinet
- Universal Logic Interface
- Parallel line printer interface
- Two HPDI disk controllers
- One 300 lpm Dataproducts line printer
- Four 1251 monochrome crts
- 56-inch communication cabinet with power supplies
- Three 8-line communication multiplexors
- Two 550 Terminals

The non-Concurrent support peripherals are as follows:

- Two Okidata keyboard printers
- SLC real time clock
- Two Central Communications Units
- 486-66Mhz PC

Some of the characteristics of the 3220 processor are outlined below:

- 400,000 instructions per second
- Eight sets of 16 32-bit general registers
- Single and double precision floating point instructions
- Bit and Byte manipulations
- Up to 2 MB memory
- 8MB/sec Direct Memory Access

The system currently uses 2 MI3 of memory under normal conditions. Approximately 1 MB is used for the operating system and 1 MB used for the UTCS database and active tasks. With the 368 intersections and 500 system detectors on-line, the system uses approximately 90% of the available cpu time.

The disk subsystem contains four 80 MB removable disk drives. One of these drives is divided to separate the system files and the temporary files. The access time on these drives is about 27 milliseconds. These drives have proven adequate for the current system loading, but like the Concurrent 3220, is using technology that is 10 to 12 years old. The current configuration of system files and traffic application files requires approximately 70% of the available disk space.

The tape drive system is a Perkin-Elmer 1600 bpi 9 track vacuum system that is used to load, backup or archive system and traffic software. This drive has proven to be adequate for the existing system with a low maintenance record. It compares well to other 9 track systems that are on the market today.

The Universal Logic Interface is a custom parallel interface that allows the Concurrent 3220 to communicate to the TOCOM Central Communications Unit. This item is a custom design and is not portable to other systems unless both the central communications unit and the Concurrent 3220 are maintained. This is an extremely difficult item to maintain since it is half populated with custom logic. The county does not own a spare and if this item were to fail, the maintaining agency would have to install the custom logic on a new ULI board. This board is used to interface the central communication units in the majority of UTCS systems across the country.

The Dataproducts 300 lpm printer has proven to be adequate for the operation of the system but is extremely noisy. Most traffic control systems are going to at least 600 lines per minute and are removing the system printer from the area where the operator controls the system.

The Perkin-Elmer 1251 monochrome terminals are used for operator input, database updates, operating system control, and system logging. These terminals operate at 19.2 kbaud and are green in color. These terminals have proven to be high maintenance items. The 486-66Mhz PC was added to the system to provide a system that the operator could use to develop the develop timing plans, UTCS database or perform normal office management and traffic engineering functions. It is connected to the Concurrent 3220 and executes a terminal emulation program to access the host computer development environment.

The SLC real time clock provides the master system time to the UTCS upon bootup. This clock is connected between the Concurrent processor and the system console. When a time request comes from the processor, the SLC enters the proper time as if the operator had entered it at the keyboard. This clock is used in the majority of the UTCS systems across the country. The system time is displayed on the wall map. Unfortunately, this unit as been dropped from the manufacturers product line and will soon become difficult to maintain.

The Okidata keyboard printer was used for system logging, reports and background processing. Each of the Okidata printers is assigned to a specific CPU.

The noise level is so high from the Concurrent 3220 computers, it was necessary to have a partial wall erected in from of the computer, to allow the operators to converse between themselves and on the phone.

**Central Computer Software**

This system is running Version 6.2 of the proprietary operating system, OS/32. This is a real-time multi-tasking operating system. This means many independent tasks can run concurrently, as long as enough processing, storage and input/output (I/O) devices are available to accommodate them. This operating system includes some custom device drivers, provided by the original system integrator, to support the CCU and full duplex terminals.

In conjunction with OS/32, the system provides the multi-terminal monitor (MTM) which is a time-sharing environment for program development. This is used by the traffic operators to update the system database, modify source files, execute performance analysis tools, or perform system management functions.

**Wall Maps**

The console is set up in front of three (3) ADC wall maps. The right-hand wall map which is approximately thirteen feet long and 9 feet high is a static map. The map on the left side and the CBD map in the center are dynamic with colored bulbs to represent green returns, controller status, or detector counts with reference to operator entered thresholds. The traffic signal controller status mode is kept on 100% of the time. The light bulbs have a relatively short life cycle. The replacement of a burned out bulb is generally a tedious task. As a test, some light bulbs have been replaced with long life LED bulbs, but they can barely be seen through the mylar map face. Vehicle occupancies at system sensors are continuously monitored, and high occupancy location are actively displayed on the wall map whenever they occur.

**UTCS Application Software**

The traffic control software is based on the Sperry Systems Management UTCS Extended system. It does contain several custom options that have been added over the years, but none have been major changes. All of these periodic updates have been implemented by Traflow Systems, Inc. in New Jersey. The UTCS (Urban Traffic Control System), was originally developed by the Federal Highway Administration (FIIWA). The intent was to provide a computerized traffic control system which could be installed in jurisdictions throughout the U.S., with only a small amount of customizing to meet the individual areas requirements. The Monroe County UTCS is an extensively modified "Extended" UTCS that was based on the Charlotte N.C. version.

The UTCS software has been revised to allow operation on a Variable Yield basis at most intersections. Through this feature, a vehicle arriving beyond the normal yield point can still be served, providing certain parameters are met. This effectively reduces the side street delay while allowing longer cycle lengths to be retained on the coordinated arterial.

The UTCS can operate in several different modes to impose timing plans on intersections or sections of intersections. These include:

- Time of Day (TOD)
- Standby
- Traffic Responsive
- Manual
- Critical Intersection Control

In TOD mode, control timing plans are automatically selected on a time of day and day of week basis. The current timing plan is selected on a once per minute basis. The system can support up to 64 timing plans.

In standby mode, intersections are monitored for correct operation, but are not under computer control. Local coordination is in effect by the time base coordinator in the controller. Proper phasing and controller movements are monitored and detector measures of effectiveness are calculated while in this mode.

In the traffic responsive mode, the computer selects the best available timing plan for each control section based on the latest smoothed traffic detector data. The system can select this timing plan on a variable time period from 5 minutes to 30 minutes. This time constraint is imposed to allow the selected plan to come on-line prior to selecting a new timing plan. This prevents the system from being in constant transition. This mode provides adaptive traffic responsive control based on historical signature data which is closest to the current smoothed data. This mode requires properly operating detectors.

The manual timing plan mode is used to force the selection of a operator requested timing plan. In this mode the intersections are under computer control. This mode can be used to override the TOD schedule that is currently in effect for reasons such as timing plan testing, special events, or check out traffic responsive timing plans or in response to incidents.

The critical intersection control mode places single intersections that saturate frequently into a mode where the splits may change once per cycle based on computed value of green demand as a function of volume and occupancy on designated links. This means that those intersections designated as critical control intersections may have the split value designated by the section control overridden as a function of the existing local demand.

The system has been expanded to support an activity scheduler that will allow the operator to schedule up to 30 commands per minute in either a temporary (the current day) or up to 10 permanent day files.

During the course of normal operation, the two console terminals are used to display a Failure Report on one and a Controller Status Report on the other. These two reports are continuously monitored by the operators, for current system status. When a problem appears, more detailed reports may be requested on either terminal.

The primary center of operator control is the control panel. The operators have become comfortable entering push-button commands, although they are allowed to enter commands and request reports through a menu system.

The software fully supports diamond interchanges and 8 phase controllers operation, but does not support lead/lag operation. The software does not support "on-line" database updates and requires that the system be taken down to add a controller, detector or change a phase.

The system supports pedestrian, fire and railroad preemption. For railroad and fire preemption, the system releases the controller during preemption and picks the controller back up after the preemption is released. For pedestrian preemption, the system allows the pedestrian time to exceed the time allocated for that interval and transitions the controller back into step during the next cycle.

**Communications**

The communications subsystem provides the lii between the Central Computer and the intersection controllers and vehicle sensors. The system uses Time Division Multiplex (TDM) equipment operating on a dedicated Coaxial-Cable Network.

Communications equipment consists of the following components: 2 TOCOM Central Communications Units (CCU); TOCOM RF Transmitter and Receiver Modules; TOCOM Field Maintenance Telephone Equipment; and a Control Corn Coaxial-Cable Network which consists of 2-way Delta-Benco Cascade Amplifiers, Redundant Loop Switches (RLS), TOCOM Pilot Signal Generators (PSG) and assorted Coaxial Cable and Taps.

Two CCU's are used in the Rochester System. Each CCU controls data on two channels. A channel is composed of one frequency unique RF transmitter and one frequency unique RF receiver.

Remote Communications Units (RCU's), located at every intersection, transmit and receive data to and from central. Up to 159 RCU's can communicate with central on one channel. Data relating controller status (phase greens, phase checks, flash, etc.) and detector (system sensor) volume and occupancy bits are transmitted to central, while the Central TCS Computer and Backup Master commands are received from central.

The Communications Equipment is designed to transmit commands to and receive status bits from each intersection twice a second.

**Central Communications Units (CCU's)**

Two CCU's are supplied with the Rochester Traffic System in order to be able to handle the eventual expansion to 600 controllers. The CCU accepts halfword-serial bit-parallel data from the ULI (Perkin-Elmer Universal Logic Interface). Data is stored in memory buffers in the CCU for half-second intervals. The transfer of Data between the ULI and CCU occurs within one millisecond. At each half-second interval the data transfer between ULI and CCU takes place (see Figure 6).

Data is converted from bit-parallel input to bit-serial output in the CCU for transmission out to the street. TTL logic is converted to the RF-frequency shift keyed (FSK) signals in the RF Modules. In the reverse direction (receive from street mode) the CCU converts bit-serial input from the RF Modules to bit-parallel outputs for transfer to the ULI.

Other functions of the CCU, include the generation of stop, start, parity and address bits, the generation of the CRC (Cyclic Redundancy Code) Status word, and the overall timing and control of all functions which take place in the CCU.

The CCU's are both custom built and limited to system expansion. These items are difficult to maintain and provide a single point of failure for the entire central system. To expand the system would require customization to the CCU and the ULI. The ULI is a "hand wire wrapped" computer board that provides the interface between the CCU and the central computer. Fortunately, the personnel at Monroe County are experienced and are able to provide the internal expertise that is necessary to keep the system fully operational. *The majority of the cities that were using this type of system have been forced to turn off the system and migrate to a different technology, due to the lack* of *qualified personnel on staff.*

**Remote Communications Units (RCU's)**

The RCU functions as a transmitter and receiver. Computer and Backup Master command data are received over the Coaxial-Cable network in the form of FSK signals, and converted to controller logic. Controller and detector status logic is converted to FSK signals and transmitted back to central.

Each RCU in the system has have its own unique combination of communications channel and local identification number which forms a unique address. The Command Data is not accepted by the RCU until a match is made between the RCU's address and the one correct address for that particular RCU generated by the CCU. When the address match is made, the associated command data be accepted. Prior to the command data being sent to the controller, the entire command message is validated by the standard CRC check. If the message is valid, then the new commands will be forwarded onto the controller. If the message is invalid, then it will be ignored.

Receipt of a valid address from central also initiates the transmit mode of the RCU. In the transmit mode, controller status and detector volume and occupancy bits are sent back to central. Since no address bits are sent back to central, the CCU relies on the proper time positioning of return words. The ninth byte, the error check character, is also formed in the RCU and sent back to central for error analysis by the CCU. This error analysis is responsible for the creation of the 5 error bits (CRC, Parity, Framing, Overrun and No-Data-Received) which are forwarded onto the computer and used in the TCS failure monitoring software. In a normally functioning RCU the TRANSMIT and RECEIVE LED's on the face of the RCU will each blink each half-second

**Communications Command Structure**

The total command sent to the RCU from Central consists of 3 bytes of data (24 bits). Sixteen bits are generated by the Traffic System Software and are transferred to the CCU via the computer - ULI interface. The remaining eight bits are reserved for backup master commands. Dial and offset commands as generated by the backup master are directly wired to the CCU. This interface completely avoids the computer subsystem.

The total return from each RCU at each intersection consists of 9 bytes (72 bits) of data. The first 8 bytes are generated at the remote intersection and this data consists of status bits for green phase, phase check, PED call and flash bits as well as system sensor return data made up of volume and occupancy bits. The last byte consists of CRC (Cyclic Redundancy Code) bits, generated and transmitted by the RCU, checked against a CCU generated CRC word, and finally used by the Traffic System Software to report erroneous returns.

**CCU Control Panel**

Two integrated control panels exist in the communications system one for each CCU. Each control panel can display the command and return status bits for every intersection (RCU) associated with the corresponding CCU. This is accomplished with the three thumbwheel switches located on each control panel.

The RCU address can be dialed up on the control panel by selecting the channel and Local-lD address. The LED's on the front face of the control panel will represent the commands bits that are being sent out.

The thumbwheel at the bottom 'RESPONSE WORD" is used to dial up the applicable return word that the operator desires to observe. The sixteen bit positions correspond to each word's 16 bits.

Whenever a call comes in or they have any problem having to do with communications or an intersection not cycling, the operators rely on this panel to diagnose the problem.

## Backup TBC

The system has an integrated TBC on the communication plant that acts as a backup in the event that the system goes down. This TBC unit sends out a sync pulse to the field units to prevent clock drift. The unit also allows for a dial, split and offset selection. This selection is normally not the timing plan that would have been selected by the central computer, but at least the controllers are kept in synchronization.

A software change has been added to provide one week historical split data on a cycle-by-cycle basis for any requested traffic signal controller. This will provide an additional diagnosis tool for the operators.

## Local Field Equipment

Most of Monroe County's controllers are either Econolite ASC8000's or Safetran 1600 series. The Safetran controllers are mostly 2 and 4 phase controllers. Monroe County was able to buy 130 ASC8000 controllers from Econolite when it was decided to drop the ASC8000's and start production on the TS2 controller. These are now being used as replacements and spares.

## Econolite Zone Monitor IV Closed Loop System

As mentioned earlier, Monroe County has an Econolite Zone Monitor IV closed loop system. The Econolite system is operating in a traffic responsive mode. The system uploads the volume data from the Masters on regularly scheduled intervals for evaluation and archiving. Priority alarms such as conflict flash conditions or "door open" alarms are sent immediately to the central computer for operator action. Currently, the system operates two active zones and one test zone, that includes 10 intersections that are along two corridors (Hylan Drive and Maiden Lane) along with one additional test zone. Monroe County hopes to expand the closed loop system to over 50 intersections in the near future.

Through the Zone Monitor system, traffic signal timing changes can be either downloaded or uploaded remotely using either the central computer or a laptop unit.

Each zone master transmits its data from a directional field antenna to an omnidirectional central antenna. The system has a problem with zone 2 that transmits over a large facility owned and operated by Kodak. The problem is being blamed on a strong RF interference at the plant. Various solutions have been tested, but the system still experiences bad communications periodically during each day.

## Field Telephone System

The Field Maintenance Telephone subsystem consists of a central RF transmitter, a central RF receiver, a central RF Down Converter, and the central and field headsets. It operates as an FM/FM telephone system.

The center tuned frequency for transmissions from central out to the street and for reception at any field location is 13.0 MHz. The center tuned frequency for transmissions from the field back to central and for reception at central is 59.3 MHz. The field headset contains RF transmitter and receiver circuitry for the appropriate frequencies, 59.3 and 13.0 MHz, respectively.

The 59.3/13.0 down converter enables two or more field sets to communicate with each other. One field headset transmits at 59.3 MHz back to central. In the central down converter this 59.3 MHz center modulated signal is converted to a 13.0 MHz center modulated signal and sent back out to the field. The second field set can then “hear” the first.

**Timing Plan Development**

Monroe County uses the standard tools available today to develop the central system timing plans. These include Transyt-7F and Passer. They also use a new product called “Synchro”, that is Windows based and provides optimization methods for calculating splits, cycle lengths and offsets. The product provides, easy to use, color time space diagrams under Windows. Monroe County is a Beta site for the product and is evaluating its performance. After the timing plans are developed, they must be manually entered into the database on a PC and then transferred to and compiled under the UTCS. This system does not have an automated database generation or conversion.

Under normal operation, the County uses standard time of day plans. There are currently several incident plans installed on the system for short segments to handle construction work zones. Additional plans are needed to handle freeway closings, ramp closings and other temporary incidents. This requires numerous engineering hours to plan and speculate possible incident areas and provide possible incident plans that could handle the infinite number of conditions. With the current system, it is cumbersome and time consuming to implement new timing plans.

The County has on the average of 12 timing plans per intersection (3 Snow plans, 2 Test plans, and 7 normal operation plans). In comparison to other UTCS facilities, this is considered to be exceptional.

**Remote Access**

Currently, the UTCS system does not have any type of remote access that could be used for interrogating the system during off hours, weekends, holidays, or by maintenance personnel. This was a problem with the majority of the UTCS systems installed across the country, since remote access has been determined to be an invaluable asset to any operating and maintaining agency. The Monroe County operations representatives indicated that they have a need for the addition of remote access into their system. This would be used by both the operators and signal technicians. The Zone Monitor system can be accessed via laptop computer.

## Control Room Malfunctions

Currently, Monroe County makes use of a standard, off-the-shelf, autodialer to call or page the operations supervisor when adverse computer room conditions are sensed. These include power outage, high temperature, low temperature, loud noise, fire alarm, water detection and computer failover (from slave to master).

## Incident Information

The major source of incident information, including HAZMAT, is from the 911 monitoring center. The operations staff is required to respond to citizen phone calls 24 hours per day. During the night, they also handle the Monroe County signal calls. This involves 638 traffic signals, 500+ loop detectors, and 24+ school flashers. The UTCS and Zone Monitor are capable of monitoring malfunctioning traffic signals.

## Maintenance

Monroe County currently pays Concurrent Computer Corporation for hardware and Tra-Flow Corporation for software maintenance. All signal system maintenance and construction is done by county personnel. This includes pulling/terminating cables and hanging signals. If a loop detector fails in mid-winter, it will remain off-line until spring, as it is nearly impossible to do any ground work during the winter. In this case, timing adjustments are performed to minimize impacts on traffic flow.

## Operational Concerns

The traffic control system is managed by a relatively new operations supervisor, who is interested in trying to fine tune the current operation, as well as look into the possibility of Critical Intersection Control (CIC) and Traffic Responsive operation. The changes will be somewhat limited since most intersections in the CBD area are running Fixed Time. Both CIC and Traffic Responsive were tried in the past; but unsuccessfully. Monroe County representatives indicated that this failure was attributed largely because it was a "system-wide" experiment and not just in a controlled area. For future evaluations, the City of Rochester has a minor league baseball stadium that draws a sizable crowd. This control section would be a good candidate for a traffic responsive operation testbed.

Another operational concern is traffic control during the frequent snow storms. The control panel actually has a command button labeled "SNOW". It was designed to adjust timing plans for slower traffic flows. In the early days, when the system was first installed, this mode was tested then deemed unacceptable. An immediate problem encountered was that the plans were never fine-tuned. The major problem encountered was that the changes were made on a system-wide basis. This strategy can be ineffective in a city like Rochester since snowfall accumulations usually vary greatly across the area. One part of Monroe County may have near blizzard conditions while another part has flurries.

Other storm oriented experiments have been made, but they too have all been system wide. The operations supervisor would like to find a test area, and try adjusting the offsets and/or splits during a major storm, while having the movements monitored by on-street observers. Another possibility would be to simply lengthen the clearance time. This would both help make up for the slower traffic and make allowance for vehicles having trouble stopping at intersections.

Dispatch and maintenance personnel have access to a highly accurate, real-time color radar system. This is used extensively for predicting weather, and its severity, that will occur during the next hour or more. If the control center had access to similar data, the operators could prepare for the storms on a sectional basis.

With access to the aforementioned radar and an expanded Roadway/Weather Information System providing detailed pavement surface information, and with the ability to both adjust signal timings and monitor traffic flow from a central location, all the elements would be present to develop effective traffic management plans for inclement conditions.

The traffic control system does allow the transmission of what the county calls a "SIGN BIT". This is actually the Special Function 1 command being sent out to selected controllers. The SF 1 command is used for various tasks. For the Rochester communication system, some controllers in certain areas are reached by more than one cable run. The County has added the ability to change coax switches in the field, to re-route communications from one cable connection to another. This is extremely useful in case of cable damage or even scheduled maintenance. Other uses of the SF 1 command is turning on "NO TURN ON RED" signs during preemption, and toggling "PED RECALL" from the central site.

**Summary of System Concerns**

- The current system is based upon late 1970s design. It utilizes broadband coaxial cable (CCTV type) for data transmission at 56 Kbps. The field controllers are custom designed RCUs (remote control units) that control the intersection timing parameters and monitor up to six volume and occupancy detectors. The central computer is a dual Concurrent 3220 central computer system running some derivative of UTCS software, that polls each RCU every l/2 second.

- Representatives from MCDOT stated that they would like to phase out the coaxial cable, since they are experiencing some reliability and maintenance problems with that sub-system. They would like to move to a fiber optic based communications sub-system. They also noted that the RCUs are "outrageously expensive" - $5000 to $6000 each - and replacement units cannot be purchased. The original manufacturer of the RCUs is no longer in business, and they have to get the RCUs custom built by a small electronics fabrication shop.

- The Concurrent 3220 computer is nearing the end of its effective life, and a software/plug compatible replacement is not available. The interface between the

Concurrent 3220 and the coaxial communications system is another piece of custom hardware that handles the unique message format and modulation technique used by the coaxial communication system.

These issues, together with the desirability of integrating the UTCS controlled signals with the Zone Monitor controlled signals, indicate the need for a large scale replacement program for the computerized traffic signal system. There are several issues that must be resolved in identifying a replacement system. Fiber optics transmission cannot readily substitute for coaxial cable because of the multi-drop technique used with the coaxial cable. The RCUs are custom devices that would have to be replicated or eliminated if the existing central system remains unmodified. The central computer is near the end of its useful life, and Long-Term system reliability and maintenance are a growing concern.

Monroe County officials indicated that they are evaluating new central computer systems that do not rely on the RCU method. This would allow for a phased transition to a new system, including gradually replacing the coaxial cable plant with other transmission media. Since the replacement system must be compatible with the freeway system, an early action item should include the identification of a recommended replacement for both the UTCS and Zone Monitor systems.

### 2. NYSDOT Closed Loop Signal Systems

NYSDOT will soon be obtaining a state-wide license for Closed-Loop Signal System Software. The software will allow centrally monitored signal coordination using the state's standard Model 179 microprocessor controllers. The Region expects to use this on corridors where retaining state maintenance is the most logical, The conversion to a centrally monitored, coordinated signal system will be relatively simple since the existing controllers can be retained. A communications link will be needed from the controllers to the central monitoring station.

### 3. Roadway/Weather Information System (RWIS)

A demonstrated project at the Ironequoit Bay Bridge, begun in 1986, saved enough in manpower and chemicals that a pay-back was achieved in about two years. The same site has been used for recent tests of anti-icing technology for the Federal Highway Administration (FHWA), and Strategic Highway Research Program (SHRP). The project was initially successful and is continuing. Early results show that low level application of chemicals just before the onset of certain types of snow and ice can provide significant benefits.

The NYSDOT has two RWIS sites in the Rochester area. These sites are located on Route 104, one is on the Irondquoit Bay Bridge and the other is two miles east of the bridge. These stations are used to predict pavement temperature for the deployment of anti-icing forces. The monitoring equipment is located at the regional headquarters, the Monroe East Residency as well as a trailer near the sites.

Communication links exist between each of the field sites and the Salt Road Sub-Residency, Monroe East Residency and the Regional office. A Central Processing Unit (CPU) at the Regional office communicates to each of the sensor sites through Remote Processing Units (RPU). The CPU calls each of the RPUs at least 100 times per day to determine if any of the various threshold parameters have been reached, as well as to do periodic updates to conform proper equipment operation. An additional CPU at the Five-Mile Line Road site has a direct link to the site's RPU. Leased telephone lines are used to link the RPUs to the CPUs and to the maintenance facilities. It is also possible to access the sensor sites from a remote location by telephone link to the CPU at the Regional Office.

The state's goal is to expand this system of roadway/pavement sensors throughout the state. These sensor sites are capable of connecting to variable message signs to display roadway conditions to the traveling public.

NYSDOT has indicated interest in relocating the RWIS monitoring equipment into the Traffic Operations Center, along with the associated highway maintenance operations staff.

The Channel 13 television station has a C-Band radar station that picks up weather related to lake effects. It would be beneficial for media and NYSDOT to share weather information.

**4. Rochester-Genesee Regional Transportation Authority**

The Rochester-Genesee Regional Transportation Authority provides approximately 55,000 trips per day serving the downtown central business district, schools and universities, hospitals and institutions. More than half of the people that utilize the transit system do not have an option to use a car. The transit routes, covering over 600 miles, are predominantly radial into and out of downtown.

Speed and punctuality are very important in operating a transit system. The RGRTA will be implementing an Automatic Vehicle Location (AVL) program that will provide for fleet management and potential real-time arrival information at certain bus stops. The two-way radios will be replaced at a cost of $2.5 million. Global Positioning System (GPS) antennae will be used with radio frequency transmitters. The use of roadside equipment may be incorporated to enhance the system. Alarms and sensors will be replaced and the data and position will be transmitted. This is anticipated to be in place by 1996. In cooperation with the City of Rochester, the Transportation Authority is considering a bus preemption/priority demonstration project on a small scale.

**5. Department of Public Safety Communications**

Within the Department of Public Safety the Communications Division is responsible for all emergency services communications. The division purchases, owns, operates and maintains the equipment. The current 96 channel analog microwave system which runs east-west through the center of the city is being replaced by a 632 channel digital system. This is a hub system with Cobb Hill as the principal hub. There are 5 major microwave towers and 40 minor sites with transmitters and receivers. There is additional capacity to add equipment to the towers. There is a backup generator which deploys after 30 seconds with no power. In the near future, completion of the 800 MHz, 9 channel system is expected.

### 6. NYSDOT Telephone System

NYSDOT Telephone System has a Wide Area Network (WAN) that connects the regional offices to Albany for data processing and CADD. The INFORM traffic management system is linked to Albany via the Empire Net. Empire Net is comprised of IBM, NYNEX and Eastern Microwave. At the regional level, the local area network (LAN) is tied into the WAN for the regional substations/maintenance facilities. The New York State Lottery uses the Empire Net to connect 8,000 lottery agents to Albany. The Empire Net is not a distance sensitive system; the points are not required to be in the same geographical region.

### 7. Office of Emergency Preparedness

The Office of Emergency Preparedness is responsible for emergency and contingency planning for Monroe County. There are twenty-five agencies from the public and private sectors that are involved in emergency responses. Decision making personnel staff the center. The office is part of the 911 protocol. The OEP has a mobile communications trailer that is used for field situations such as hazardous material spills. There are backup generators and separate electrical sources to power the communications system. The communications links are strong and diverse with outlets to commercial radio and television. The level of participation and cooperation is very good, probably due to the close proximity of the nuclear power plant in Wayne County.

### 8. EZPass

The EZPass Toll Collection system began in August of 1993 at the Tappan Zee Bridge and at selected toll plaza locations along the NYS Thruway. Presently, there are approximately 90,000 toll tags in use with 67,000 accounts. Approximately 56,000 tags are in the Rockland/Westchester are and 26,000 tags in the Buffalo area. EZPass also recently began operations in the Albany area. Six (6) toll collection facilities are equipped with EZPass tag readers. Additionally, 3 facilities will be added next year. Right now only tolling facilities with fixed fees are using the EZPass system. Soon EZPass will be added to the variable ticketing systems. The equipment is leased from AMTech. Vehicles average 8 to 9 mph through the toll barriers. The posted limit is 5 mph in consideration of the toll workers' safety. At the Tappan Zee Bridge all 13 toll booths are equipped with the readers for flexibility. During the peak period, 5 booths are using EZPass. The administrator of the system is Lockheed IMS. Originally, the signing to direct EZPass customers to the correct booth was confusing. Red LED variable message signs have been replaced with simple drum signs that change messages using overhead garage door openers. There is a $10 deposit and a $1 per month fee along with the same toll structure. The estimated monthly tolls are prepaid one month in advance. The toll discounts at the Tappan Zee Bridge also apply to EZPass customers. The balance on an account can go as low as $5 if the account is paid by credit card and as low as $10 if paid by cash or check. There is a $5 penalty charge if the balance falls below the minimum or into a negative balance. On the Tappan Zee Bridge during the morning rush hours of 6:00 a m. to 9:00 a.m., 75 percent of the tolls are paid with the EZPass system. On average for the day, 40 percent of all tolls on the Tappan Zee Bridge are paid by EZPass. A manual or manned toll booth can serve 350 vehicles per hour, automatic or exact change can serve 650 vehicles per hour and the EZPass lanes can serve 950 vehicles per hour with greater than 99.95 percent accuracy. The Rochester area is expected to be one of the areas where the EZPass to 11 tag technology is implemented on the NYS Thruway.

## 9. TRANSMIT

There are 20 readers along the Garden State Parkway from the Hillsdale toll plaza to the NY State line and the NYS Thruway from the Spring Valley toll plaza to the Tappan Zee Bridge covering 19 miles as well as some of the major off ramps. These readers are used to read the more than 50,000 EZPass tagged vehicles that use these roads. The vehicles equipped with the EZPass tags are used as probes along the highway for incident detection. Seven (7) of the reader locations in NJ are individually, directly linked to TRANSCOM while the remaining 13 locations in NY are grouped at one location or hub and then sent to TRANSCOM who hosts the central computer that performs the calculations. TRANSCOM operates 24 hours per day, 7 days per week. The New Jersey Highway Authority, TRANSCOM and the New York State Thruway each have an operations center. Within close proximity to the Tappan Zee Bridge 75 to 90 percent of the peak hour traffic is equipped with the tags. The system samples 10 vehicles every 10 to 20 seconds, 1500 to 1800 vehicles per hour during the peak period. The incident detection system runs with a 70 percent confidence level. The full operational system was completed in early 1995. The type of incident detection may be applicable in the Rochester area; once EZPass technology gets into more wide spread use.

# CHAPTER II

# EXISTING AND FUTURE CONDITIONS/ INSTITUTIONAL ISSUES/ USERS NEEDS

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# II. EXISTING AND FUTURE CONDITIONS / INSTITUTIONAL ISSUES / USER NEEDS

## A. Roadway Network

The Rochester ATMS study area, mostly Monroe County, is made up of thousands of miles of roadway, from interstates and expressways to local distributor roads. These roads are under a variety of jurisdictions, including New York State, Monroe County, various towns, and the City of Rochester. The traffic signals in this area also fall under state and county, with some signals managed by the county-maintained Urban Traffic Control System (UTCS) and the Zone Monitor System.

The majority of information about the roadway network, including existing volumes and accident data, was gathered from a wide variety of sources. These sources include:

The New York State Department of Transportation (NYSDOT)
The Monroe County Department of Transportation (MCDOT)
The Genesee Transportation Council (GTC)
The 1993 New York State Highway Sufficiency Ratings
New York State Intersection Master Listing
NYSDOT Reference Marker Maps
NYSDOT - Highway Sections Rated by Accident Rate
Interviews with local official, businesses, departments of transportation, etc.
The GTC Draft 20 15 Long Range Plan
The GTC Rochester Area Traffic Simulation Model
Aerial photography and analysis

The Rochester ATMS study concentrates on interstates, freeways and major arterials. These roads are divided into two categories, primary and secondary routes.

### 1. Primary Routes

The primary routes are predominately freeways and interstates, providing access to and around most areas in the Greater Rochester Area. The primary routes represent the highest traffic volume corridors and carry a high portion of the total urban traffic. Most trips to and from the CBD, other major activity centers, and major suburban centers utilize these primary routes.

Most of the primary routes are full access-controlled facilities with four to six lanes and relatively high free flow speeds. Most routes are limited access routes with no signalization, full shoulders and high design standards. Table 1 in Appendix A lists all primary routes and a variety of information about each route. Each route is broken down into sections where information such as road type, existence of shoulders, number of lanes, and lane-miles is given. Also, found in these tables are volume and accident information, which is discussed in the next few sections of this report. It should be noted that the roadways are broken into sections according to reference markers. Reference markers are the method used by the New York State Department of Transportation (NYSDOT) to delineate all roads under NYSDOT jurisdiction.

**Aerial Traffic Surveillance**

Aerial traffic survey photography of the primary routes was taken during the AM and PM peak hours in the spring of 1994. These photos were analyzed to provide estimates of level of service (LOS) and traffic flows for the route sections.

| Limited access quality | Density range: | Rating (LOS) |
|---|---|---|
| Light | 0-10 | A |
| Light-mod | **10-20** | B |
| Moderate | 20-30 | C |
| Mod.-heavy | 30-40 | D |

At densities above 40 passenger cars per lane per mile, traffic begins to slow due to the proximity of other vehicles; rather than using LOS ratings "E" and "F" for these densities, we have chosen to present actual densities; these provide more information about the severity of the congestion:

| Limited access quality | Density range: | Typical speed ranges |
|---|---|---|
| Heavy | 40-60 | 60-30 mph |
| Congested | 60-80 | 40-20 mph |
| Congested | 80-100 | 30-10 mph |
| (Severe) | 100- 140 | 15-5 mph |
| (Severe) | above 140 (rarely found) | under 5 mph |

Levels-of-service "A" through "F" are also commonly used for arterial highways (those with traffic signals), but defining criteria are based on travel speeds and through put at the intersection, not densities. Since travel speeds cannot be easily measured from aerial photographs, arterial level-of-service cannot be obtained using this methodology. Nevertheless qualitative assessments of traffic quality -- light, moderate, heavy and congested -- can be made by looking at the aerial photographs. In order to standardize these judgments, we have defined them in terms of density, and have used the same ranges listed above for the limited-access highway system.

**Technical Methodology: Data Reduction & Processing, and Report Preparation**

From the time-stamped photographs, densities by highway segment were determined by one of two methods. For stable traffic flow conditions (densities of less than 40 pcplpm), densities in increments of 10 were established through the use of the "calibrated eyeballs" of speciallytrained personnel; this procedure expedited data reduction and in most cases produced the same service level ratings as would have been obtained by actual counts. For densities greater than 40, actual counts were taken. Data that were atypical due to known or suspected incidents, roadwork or for other reasons were coded for exclusion from the averaging process. All data were entered into a microcomputer database program, which 1) grouped samples by 45 minute period; 2) calculated average densities; and 3) converted them into traffic quality ratings A through F. The computer next prepared matrices showing each averaged service level rating plotted by time and highway segment. These data matrices were then copied into density contour maps, which are the basis for this report.

Figures II-1 through II-3 show the LOS's and traffic flows measured for the peak hours. These figures also show areas where heavy and congested traffic flows were observed. Congested and heavy traffic flow route segments may also be determined by reviewing average annual daily traffic (AADT) volumes and volume to capacity ratios (v/c) in Tables 1 and 2 in Appendix A.

### 2. Secondary Routes

Generally, secondary routes are major arterials. In many instances the secondary routes parallel the primary routes, providing alternate access to and from the CBD, other major activity centers and major suburban centers.

The secondary routes are predominantly uncontrolled access facilities, ranging from two to four lanes with design speeds and standards typically lower than that of their primary route counterparts. Most secondary routes have a number of signalized intersections and sign controlled side streets and driveways. While most primary routes fall under NYSDOT jurisdiction the secondary routes are a mix of state, county, and city roads. This mix of jurisdictions also exists for the signals along these secondary routes. Table 2 in Appendix A lists all secondary routes and a variety of information about the routes. The secondary route tables follow the same format as the primary route tables discussed in the previous section.

Appendix A provides insight into areas of congestion and heavy traffic flows on the alternate routes. Since the roadways are broken down in relatively small sections for which AADT data and v/c ratios are given, an accurate representation of traffic flows may be gained. In addition, intersection volume counts, not represented in the table, used to determine traffic flows and LOS have been gathered for various intersections on the alternate routes.

## B. Existing Traffic Volumes

Existing volumes were obtained from a variety of sources which are listed in the previous section. Data for state, county, and city routes have been obtained. This includes various intersection counts, tube counts, projections from older counts, aerial photography and continuous count stations. It should be noted that the freeway system contains only four continuous count stations, located on Route 53 1, I-490, Route 590, and Route 3 1. The remaining count data is obtained from the state's count program. The primary and alternate route tables contain estimated Average Annual Daily Traffic (AADT) for roadway sections.

Traffic volumes for many intersections and roadway sections, available for various dates and times, are available, but not reflected in the table. The arterials on the UTCS and Zone Monitor have several hundred count stations. The AADT may be used to locate areas which have high traffic volumes and carry a large portion of the overall network's traffic volume.

In general the primary routes (freeways) carry more traffic than the secondary routes (arterials). This is expected, considering the types of facilities in each class. The secondary routes have AADT from approximately 4,000 vehicles per day (vpd) (Route 404/Salt Road) to more than 3 1,000 vpd (Route 15A at Route 15). The majority of AADT are found to be in the 13,000 vpd to 25,000 vpd range. Primary routes vary in AADT with some as high as 132,000 vpd (1490/1590 Interchange) to others with as little as 13,000 vpd (I-490 at the Monroe County/Genesee County Line); although many of the primary routes exceed 50,000 vpd. The primary routes having the lower AADT tend to be the few routes which would be defined as arterials. Even though the primary routes carry higher traffic volumes than the secondary routes, this does not mean they operate with lower LOS. The alternate routes have lower capacities which causes less additional traffic to degrade the LOS than required on the primary routes.

Recurring congestion is associated with roadway segments that experience the same type of congestion at the same location, usually during the peak periods. The criteria to determine areas of recurring congestion was based upon the peak period percentage of the AADT and the volume to capacity ratios for the particular roadway type. Recurring congestion occurs when the facility experience Levels of Service LOS E/F.

| RECURRING CONGESTION CRITERIA<br>FREEWAY/INTERSTATE | DIVIDED ARTERIAL | UNDIVIDED ARTERIAL |
|---|---|---|
| 15,000 ADT / LANE | 10,000 ADT / LANE | 7,500 ADT / LANE |
| LOS E / F | LOS E / F | LOS E / F |

## C. Existing Accident Data

Existing accident data was obtained from two main sources, NYSDOT and MCDOT. NYSDOT was able to provide accident data for all primary routes and the majority of alternate routes. MCDOT was able to provide accident data on those portions of the alternate routes where NYSDOT does not maintain accident data.

The NYSDOT accident data was provided in the form of the Highway Sections Rated by Accident Rates. These NYSDOT accident tables divided the roadways into sections. The tables gave both total accidents and accident ratings for each section. The accident ratings used are below average, above average, safety deficient locations, and priority investigation locations (PILs). PILs are areas were there is a high confidence that accident rates exceed average or expected rates and remediation measures are under consideration.

The NYSDOT accident data provides a means by which roadway sections where incidents are likely to occur may be identified. Either by the high number of total incidents or the sections exceeding expected accident rates. Tables 1 and 2, discussed in the previous sections, list the total number of accidents on each roadway section along with accidents per lane mile. Locations such as Route 3 1 at the Route 96 Intersection with nearly 65 accidents per lane-mile, Route 104 at Route 18 with 70 accidents per lane-mile and Route 3 1 at the intersection with Route 250 with over 63 accidents per lane-mile are the top accident locations in the study area under this measuring criteria. These high accident areas are approximately l/10 of one mile in length and vary from 2 or 6 lanes.

The MCDOT accident data is not as detailed as the NYSDOT accident data. The number of accidents over a section of roadway is given, although the roadway sections tend to be longer then those in the NYSDOT accident data. Accident ratings, such as PIL and SDL, are not available for the MCDOT section. The presence of a large quantity of accidents or a high ratio of accidents per lane mile; however, still provides an excellent indicator of areas where incidents are likely.

Nonrecurring congestion is associated with accidents and is less predictable than recurring congestion. The criteria is based upon the average number of accidents that occur along a roadway segment. The usual "Accidents per Million Vehicle Miles Traveled" data is not a criteria that provides the frequency of accidents at a location. In order to determine the amount of delay associated with nonrecurring congestion, the frequency of accidents was used. The volume criteria was lowered to a Level of Service D, because accidents have an affect on traffic at Level of Service D as well as LOS E / F.

| NONRECURRING CONGESTION CRITERIA<br>FREEWAY/INTERSTATE | DIVIDED ARTERIAL | UNDIVIDED ARTERIAL |
|---|---|---|
| 12,000 ADT / LANE | 8,000 ADT / LANE | 5,000 ADT / LANE |
| 7-8 ACCIDENTS/LANE MILE | 11-12 ACCIDENTS/LANE MILE | 14-15 ACCIDENT/LANE MILE |
| LOS D, E/F | LOS D, E/F | LOS D, E/F |

## D. Special Facilities/Critical Locations

Rochester has a wide variety of amenities and special facilities enhancing the quality of life in this area. These include hospitals, universities, a major sports stadium, and large industrial and commercial sites. The following is a listing of major routes and some of the special facilities to which they provide access.

- Route 15 - Highland Hospital, commercial development
- Route 96 - Nazareth College, University Business Center
- Route 104 - Kodak Park, Rochester General Hospital, Silver Stadium, Xerox Wilson Center for Technology, major commercial developments
- Route 252 - Rochester Inst. of Tech., major commercial and industrial development
- Route 390 - Kodak Park, Park Ridge Hospital
- I-390 - Univ. of Rochester, Monroe Comm. College., Monroe Comm. Hospital, Rochester Psychiatric Hospital, Strong Memorial Hospital, Greater Rochester International Airport
- I-490 - St. John Fisher College, Genesee Hospital, CBD
- Route 531 - Eastman Kodak Company Elmgrove Site
- Inner Loop- Civic Center, New Baseball Stadium, Downtown Area

For the purpose of this study, a critical location is an area with a high rate of incidents per lane mile, since incidents are a major contributing factor to congestion and traffic flow problems. Making improvements, such as installing incident detection equipment and traveler information equipment at these critical locations, will provide improved travel times and reduced traveler delays due to incidents. Accidents are identified from the NYSDOT accident data for the two year period January 1, 1991 to December 3 1,1992 The average number of accidents over the two year period was used for analysis purposes.

Critical locations shown in Table II-l, identified to be roadway sections exceeding the 85th percentile of accident rates per lane-mile, were identified. The locations with rates greater than the 85th percentile value of 18 accidents per lane mile for primary routes and 30 accidents per lane mile for the alternate routes are consider to be the critical locations which should be addressed.

It should be noted that, in general, accident rates for the primary routes are approximately half of the alternate route rates. The primary routes rates ranged from 70 to 0 accidents per lane mile while the alternate route accident rates ranged from 140 to 0.77 accidents per lane mile. In both route types, only a small number of the routes demonstrated the high accident rates. Accidents per lane mile rates are shown for all sections in the tables in Appendix A.

## TABLE II-1 CRITICAL LOCATIONS

| PRIMARY ROUTES | | ALTERNATE ROUTES | |
|---|---|---|---|
| ROUTE | (SECTION) LOCATION | ROUTE | (SECTION) LOCATION |
| Rte 104 | (14) Rte 18 Intersection | Rte 15A | (116) Jefferson Rd Intersection |
| Rte 31 | (3) Rte 96 Intersection | Rte 31 | (131) Elmgrove Rd Intersection |
| Rte 31 | (7) Rte 250 | Rte 31 | (133) Long Pond Rd Intersection |
| Rte 104 | (10) Rte 390 Interchange | Rte 33 | (148) Rte 259 Intersection |
| 490I | (73) 441 Interchange | Rte 15 | (107)Rte 252 Intersection |
| Rte 390 | (26) 490I/390I Interchange | Rte 31 | (129) Manitou Rd Intersection |
| 490I | (63) Mt. Read Interchange | Rte 31 | (139)Chestnut St. to City Ln |
| 390I | (35) Hylan Drive Interchange | Rte 15 | (109)390I Interchange |
| Rte 104 | (11) Between 390 and Mt. Read Interchanges | Rte 33A | (167) Rte 204 Intersection |
| Rte 31 | (1)590I Interchange | Rte 31 | (127)Gillete Rd Intersection |
| Rte 104 | (12) Mt. Read Interchange | Rte 33 | (156) West Ave to Broad St. |
| Rte 104 | (15) East of Rte 18 | Route 18 | (124) Dewey Rd |
| Rte 104 | (9) Between Rte 261 and Rte 390 Interchanges | Rte 15A | (113) Lehigh Sta. Rd |
| 390I | (46) Rte 33A Interchange | Route 31 | (137) City Ln to Broad St. |
| Rte 390 | (27) Rte 31 Interchange | Rte 31 | (135) Rte 390 Interchange |
| Rte 104 | (8) Rte 261 Interchange | Rte 31 | (134) Between Long Pond and Rte 390 |
| | | Rte 15 | (103) Erie Station Intersection |

*Note: (Section #) - See Tables 1 and 2, Appendix A*

Local knowledge and familiarity with the area is another aspect of identifying critical locations. Many of the project participants live in the Rochester area and drive the study area on a daily basis. This personal involvement plus engineering judgment help in identifying or verifying special facilities and critical locations.

Based on this perspective, two general comments were made regarding the aerial photographs and their analysis. The first focused on interchanges, where heavy traffic volumes were observed on the off-ramps, while heavy volumes on adjacent on-ramps and arterials in the interchange were not observed where expected. The second comment related to the operating LOS predicted using vehicle densities from the aerial photographs at several lane drop sections where the outside mainline lane became a ramp to another expressway. Under this scenario, the volumes determined from the aerial photos indicate a LOS of C if all three lanes were used, however, local experience observed that the majority of traffic uses only two of the three lanes making the LOS for each of the two lanes lower than predicted. Local familiarity also report about effects of recent challenges to the roadway network. For example, the recent opening of the Route 53 1 expressway extension, significant increases in volume and congestion have been observed on I-490 between the 53 1 connection and I-390 interchange. This is not reflected in the current aerial photography. Also there are roadway sections where the aerial photos seem to demonstrate a better LOS than what local experience suggests. This is seen on sections of Route 104 in the town of Greece and Route 31 in the town of Pittsford.

Local knowledge and input was obtained by the use of several methods. Project personnel familiar with the area reviewed and commented on information such as the aerial photography. Also, local, county and state officials, business representatives, local transportation engineers, and other interested parties were interviewed to determine other end-user perspectives on special facilities and critical locations.

**E. Transit Network**

The Rochester area has a long history of Transit service utilizing most modes of transportation, including a subway system operated until the late 1950's. Currently the transit system in the Rochester area consists exclusively of buses. The Rochester area is serviced by two subsidiaries of the Rochester-Genesee Regional Transportation Authority (R-GRTA), providing fixed-route and paratransit bus services.

The Regional Transit Service (RTS) is the largest of the R-GRTA subsidiaries and one of the two subsidiaries operating in the Rochester Area. RTS operates a fleet of 225 buses providing fixed-route bus service 21 hours a day, seven days a week. Along with the entire city of Rochester and every town in Monroe county, RTS provides service to portions of Genesee, Livingston, Ontario, and Wayne counties. Figure II-4 displays all RTS bus routes, showing most bus routes to be radial and oriented to or from downtown Rochester. RTS has some 3,500 bus stops with about 125 of the stops having some type of shelter.

With a fleet of 225 buses, RTS currently carries about 13-million passengers a year (or 55,000 passengers daily) with passengers predominantly being "transit-dependent", that is, most passengers have no other means of transportation available to them. RTS has experienced a decline in passengers over the past 15 years with the current yearly passenger volume only sixty-five percent of that in 1980. Very few buses travel on the freeway system; predominant routing is radial in and out of the Central Business District on the arterials. The RTS is in the process of installing a Global Positioning System (GPS) based vehicle location system which is expected to be in place in early 1996.

**F. Future Conditions**

The amount of transportation data available for the Rochester area is unique for the size of the metropolitan area. This data offers an excellent base to derive the expected future traffic conditions. The Genesee Transportation Council (GTC) has developed a traffic simulation model of the existing PM peak hour of the Greater Rochester area. This model utilizes the TMODEL2 computer program that uses geographic land use zones and the highway network to simulate PM peak hour traffic movements. GTC has calibrated the model utilizing numerous factors to depict if when, and where people make trips. In addition to the existing conditions, GTC has also modeled future conditions. This model of the future conditions contains all programmed highway improvement projects (widening, new roads, etc.), such as the I-490 widening project from Route 441 to Route 96. It has also accounted for anticipated household and employment changes for the future (1995 and 2015) conditions. From the GTC model, growth rates can be extracted and applied to the ATMS study area network. The factored volumes may be used to project congestion locations and critical areas. The GTC has also prepared a Draft 20 15 Long Range Plan which describes anticipated changes in factors such as employment, households, and household vehicles along with development, environmental, and growth patterns.

Predicting the characteristics of the future conditions of transit is more difficult. While plans for revising and revitalizing the bus system do exist, and the reopening of the subway has been discussed, the extent of the necessary large community support is unknown and large community investment in transit is not expected at this time. Using existing conditions as a guide, the current predication for the future of transit is that it will not increase its share of total trips taken and will possibly decrease.

## G. Initial Evaluation of Institutional Issues

### 1. Introduction

One of the early tasks in developing the institutional issues for the "Rochester Areawide Advanced Transportation Management System" study involves an inventory of the current regional ITS activities. As part of this effort, a series of interviews were held with relevant current or potential ITS users in the region. Through the interviews, an understanding was gained of the various agencies' perspectives, roles and priorities related to the implementation of the various agencies' perspectives, roles and priorities related to the implementation of ITS in the study area. The initial agencies interviewed included:

New York State Department of Transportation
Monroe County Department of Transportation
City of Rochester Engineering Bureau
Regional Transit Authority
Genesee Transportation Council
New York State Thruway Authority
Monroe County's "911" network
Office of Emergency Preparedness

Although these are the major players in the region, other interviews were conducted based on recommendations from the interviewees and others. Most of the interviews were conducted one-on-one, however, when that was not feasible, telephone interviews were conducted. Summaries were prepared for each of the interviews. Drafts of the interviews were sent to the interviewees to allow them the opportunity to add comments. The actual notes from the interviews as well as the list of interviewees can be found in Appendix B.

## 2. Summary of the Local Institutional Issues and Needs

This section summarizes the interviews and highlights some of the issues that will need to be addressed during this study regarding the Region's and Department's institutional issues as well as what the area's agencies and potential users of a regional system see the ATMS providing

- Everyone interviewed agreed that the Greater Rochester area does not yet have significant congestion problems, but they want to have the ability to avoid traffic congestion as the area grows. There is an understanding that drivers have a "perception" of congestion that must be addressed. The number one agenda item is to preserve the "quality of life" in the Rochester area. A unified, modern reliable communication network is at the top of all the interviewees lists.

- Almost all those interviewed were in agreement on most of the issues related to ATMS. There were a few differences of opinion, such as what roadway networks should be included in the ATMS Plan and the level of formality of agreements needed among the agencies.

- There is a need for improved communications between various agencies and to the public. This communication should be in the form of real-time traffic and incident information with special emphasis given to incident management and construction detours. Motorists need to be able to make choices at points in both time and location to allow them to make intelligent decisions. This pertains not only to incident management, but also to emergency evacuations. The expansion and haring of regional communication systems in both the public and private sector is important.

- There is a perception that communications are presently controlled by the County through the Public Safety Office, which is the hub of all communications other than the Department of Transportation. A decision needs to be made on the best type communication system as well as who controls the dissemination of information. It is very important to have a backup of communication links in times of emergency.

- Currently, there are several different communications systems in use in the Rochester area including cellular phones, land lines, 2-way radio, coaxial cable and fiber optics. Every agency appears to be going in its own direction with their communications systems. Several agencies are already in the process of upgrading their communication networks without any regard to regional network needs.

- Decisions on communications systems need to be made at an early stage, as the County is moving towards having a unified system. The NYSDOT should work hand in hand with the County to ensure the future optimal use of a communication network for the ATMS. Everyone must be on the same system and have the same protocols and standardization (although some agencies want separate control). The same protocols should be used by all agencies for notification of emergencies to ensure rapid and proper response and to avoid duplication of services. Standardized communications need to be established. Protocols can be established in conjunction with the proposed control center. Everyone should be able to utilize the system both for direct communication as well as for redundancy. Since a network of fiber optics exists, it is logical to build upon this existing network. Pure Waters has a north/south fiber optic system that runs for approximately eight miles. They have indicated that traffic information could be run on some of the fibers not presently begin used by them.

- All services should be coordinated so that they appear to function as one "seamless" entity.

- Early weather detection and pavement monitoring is important to everyone. It provides the area with a means to be pro-active. There needs to be a way to deliver messages to the public on aspects of the system, such as automatic speed limit changes based on the temperature of pavement, and icing conditions on the road as examples.

- The Expressway Committee is generally viewed favorably. However, almost all participants felt it should be more active in the development of the ATMS and future Incident Management planning.

  Agencies generally coordinate well on an informal basis, but each has its own agenda. The existence of the nuclear power plant seems to drive the sophistication of the cooperation. It is essential to have the cooperation of all County, City and State agencies. The coordination of services would remove duplication, such as currently exists with the many law enforcement agencies and communications systems in the greater Rochester area.

- The current system of informal agreements between the various agencies has worked well to date. However, there are a range of opinions on whether an informal system would work with ATMS. The multi-jurisdictional nature of ATMS generally requires that more formal agreements in place would provide a clear line of responsibility for procurement, installation, operations and maintenance. There is a need for a clear definition of who will control ATMS and how it will be coordinated with the existing systems. An intergovernmental decision-making body could be established so that everyone is on the same playing field.

- Many of the participants felt the Thruway and Expressway should be included on the new ATMS system, but not everyone is in agreement regarding the Thruway. Some felt there should be a transit tie-in to all communications networks so transit is perceived as part of the system.

- Everyone was in agreement that the users and the general public must be educated on the benefits of the technology. Another concern was what data should be shared with the public/media and how it-should be transmitted. Should the public/media be given "raw" data or the "facts"? Should the data be transmitted to the public through the media or by other means? The legal questions this poses, such as liability, are also an issue.

- The amount of data that is necessary to do the job correctly and its cost effectiveness needs to be determined. What is essential data to allow decision-makers to set policy and the public to make correct decisions about their travel patterns? Is the cost of this data worth the real or perceived benefits? What is the best way to provide services to the community?

- A need for video cameras, especially for incident management, was expressed. Response equipment should be available for use by all and should include central dispatching as needed. Access to speeds by link/segment/time of day/time of year/etc. would be very useful.

- An area that had wide support by all of those interviewed is public/private partnerships. It was felt that partnerships are a good possibility but it needs to have an innovative approach. No possibilities should be left unexplored. The NYSDOT should make use of the academic institutions and imaging industries that populate the region. Areas of possible public/private partnerships include Research and Development, turnkey operations, and information dissemination.

- The project should have a good impact and capture the imagination of people, as well as being useful and functional The expectations for the project are improved incident management, enhanced and expanded RWIS, and a unified communications system.

### 3. Political and Legal Concerns

This section describes the broader regulatory and organization process obstacles to Advanced Transportation Management Systems. These are discussed from the perspective of NYSDOT.

ATMSs are typically found in the public sector so that many issues that arise have political repercussions. Since many of the applications are in their infancy, there may also be legal implications.

The following areas are concerns that appear to need resolution regarding political and legal issues involving ATMS:

- Political Barriers to Partnerships: NYSDOT lacks broad experience working with private partnerships dealing in ATMS technology. This could lead to political pressure.

- Access to NYSDOT's Rights-of-Way: Statutes and policy are both subject to interpretation.

- Participation of Other Governments, Agencies, or Firms in Regionally Coordinated Efforts: This issue deals with associations developed with others outside the Department.

- Anti-trust Legislation: The threat of violating anti-trust legislation by unjust collusion exists. However, the National Cooperative Research Act of 1984 reduces the potential antitrust liability for certain research and development joint ventures.

  Intellectual Property and Proprietary Technology: The rights for both the public and private sectors are not clearly defined at present. FHWA's interpretation of what is public property may discourage investment.

  Invasion of Individual's Privacy: There is concern that some ATMS technology applications may affect national and/or state right to privacy provisions.

  Information Discrimination: There are unanswered questions regarding various potential forms of information discrimination including social, economic, regional, and demographic.

- Potential Liability: The increased automation resulting from the adoption of certain ATMS technologies could shift liability to the developers and operators, especially of automated highways.

- Legislative Requirements: NYSDOT seems to be committed to the provisions of ISTEA through ATMS applications.

- Customer Satisfaction: This a major concern and drives the applications of ATMS. The FHWA has stated that user satisfaction with services needs to become a key evaluation tool.

Initial Recommendations:

- NYSDOT should evaluate in detail the choices and implications a) of forming partnerships with other public and/or with private organizations, and b) of granting access to its rights-of-way.

- NYSDOT should pursue changes which would provide the flexibility needed to attain the objectives of the ATMS.

- The Department should take precautions to prevent creating a monopoly with its partnerships and invading personal privacy by the use of video and record keeping technology.

- Public/private relations present their own set of concerns. There are a range of opinions on the types of partnerships that should be formed. Often there are "culture clashes" in public/private partnerships. Private sector companies are mostly market driven, whereas the public sector must respond to multiple Federal, State and local jurisdictions' specifications, regulations, and processes. It has been suggested that the Department make use of the imaging capabilities in the Rochester area for Research and Development and possibly installation and training.

- NYSDOT should promote additional channels of communication for ATMS within the Department and among agencies, organizations, and customers.

**4. Project Selection and Development**

Project selection and development is another area of ATMS that presently requires attention. In the relatively short time since ISTEA, many states, including New York, have found ITS projects becoming a major component of their capital and operating budgets. States vary considerably in their approach to project selection and development for ATMS projects. Techniques include a) use of outside consultants, b) internal cross-functional teams, c) a variety of committee setups, meetings, and workshops, and d) advisory committees comprised of local officials and citizens.

The existing project development process may not work for ATMS projects, because they have different requirements in scope and effort. Therefore, new approaches to project selection and development should be explored. This project may provide the opportunity to set the process for project selection. Similarly, the opportunities for public/private partnerships, as well as the role of the private sector in project development are still not clear.

Initial Recommendations:

The goal should ultimately be to integrate ATMS project needs into the existing project selection and development process similar to traditional projects. ATMS programs will require a special emphasis resulting from their higher costs, new applications, and changing technology. Any ATMS project must ultimately be part of the TIP (Transportation Improvement Program).

NYSDOT could establish an internal multi-disciplinary ATMS Committee. This committee would help develop a collaborative ATMS process and ensure that all the relevant players participate in it. The Committee should be supported by an advisory committee of local officials, citizens, and key external agencies, such as the Expressway Committee in Rochester. They would provide a arena for a coalition of interested parties.

**5. Evaluation**

All public projects of any magnitude should be evaluated to see whether they meet the goals and objectives of the agency. Public agencies have a track record of taking a conservative approach to innovations until the benefits are proven. The nature of ATMS projects is such that benefits are not always clear or quantifiable. NYSDOT is willing to undertake its projects, given the availability of federal capital funds and its own goals.

Many feel that the ATMS project will have a major impact on the "quality of life" in the Rochester area, as well as provide multiple users with more access to communications networks. This somehow must be incorporated into the evaluation process.

InitialRecommendations

- Operating and capital budgets should reflect the goals, strategies and actions needed for ATMS to meet customer and Department needs.

- Early evaluation methods should be developed to determine if the project is meeting the Department's and user's expectations.

**6. Funding**

Considerable ISTEA funding for ATMS type projects has been made available, either through the flexibility afforded States under other categorical grant programs or through demonstration projects. In question is whether federal funds will continue to be available for these purposes. If funds continue to be available, the levels of this funding is presently unknown. Equally at issue is the level of state funding which will be needed to support the maintenance and operation of the ATMS project.

NYSDOT should consider collocating with other agencies such as the State Police and Monroe County DOT to help share the cost of constructing and operating the TOC.

Opportunities for research funding in the area of inclement weather traffic management should be considered to help defray TOC operating costs.

There is a wide variety of federal, state, and corporate funding sources being used by states investing in ATMS projects. NYSDOT's ability to form partnerships with other organizations to help this funding scenario is limited by certain legislative and/or regulatory restrictions. The restrictions also discourage private companies from desiring such partnerships, and designate funds for narrowly specified uses. NYSDOT already has acknowledged that what is implemented must be maintained and thus will require a stable funding source for Long-Term maintenance and operation.

Initial Recommendations:

- NYSDOT should continue to support maximum flexibility in the use of federal funds, including future appropriations, for federal operation and maintenance costs.

- NYSDOT needs to identify and capture a stable source of funding for ATMS operations and maintenance.

**7. Procurement**

Procurement specialists are being challenged by the rapidly increasing need for public agencies to procure rapidly changing sophisticated ATMS technology. It raises a host of questions including in-house evaluative expertise, use of functional performance specifications, time sensitivity, and life cycle cost analysis. Under New York law, the "lowest bid from a responsible bidder" concept must be applied regardless of what is being purchased. Purchasing systems and procedures typically are not set up to move quickly or to enable a great amount of flexibility in the procurement of ATMS material. In addition, more sophisticated and complex purchases are straining the level of the buyer's technical expertise.

Initial Recommendations:

- Where applicable, the Department should work to change current policies and legislation, regarding the "lowest responsible bid" concept, to allow acquisitions based on life cycle costs, product quality, functional performance, and vendor reputation, where they may be advantageous to the State.

- The potential of leasing as an alternative to buying, especially for high cost, rapidly changing technology, should be considered as part of the purchasing process.

**8. Staffing and Training**

At NYSDOT and other public agencies staffing and training are becoming more important as the requirements for ATMS expertise change and grow. NYSDOT is focusing on increased in-house capability through re-training of employees from other areas and hiring highly-trained individuals as others retire.

Initial Recommendations:

- The Department should pursue a closer relationship with area universities to develop cooperative teaching and research within the transportation planning, engineering, electrical, and computer systems engineering curricula specifically aimed at ATMS applications.

  Co-location with other agencies such as the State Police and Monroe County DOT should be considered to minimize the number of personnel needed through shared resources and to maximize communications and cross training.

**9. Maintenance**

Decisions on ATMS facilities and equipment cannot be judged solely on capital outlay, but must include cost and other considerations regarding their continued maintenance. It is increasingly important that designers allow for open architecture and modularity in order to facilitate maintenance flexibility and compatibility among systems and equipment.

Initial Recommendations:

- A top priority at NYSDOT, in order to achieve operational reliability, must be the proper maintenance of ATMS systems.

- The Department should seek increased coordination with regional and national groups in order to develop and build compatible modular systems in an open architecture environment.

- NYSDOT should maintain its own equipment whenever possible and feasible. The advantages are improved control, a broader knowledge base within the Department and, in some cases, more cost effectiveness.

### 10. Centralization Versus Decentralization

One of the major questions facing agencies is whether projects are developed, constructed, and/or operated from a central location, both physically and organizationally, or whether there are parts of the process which are left principally to decentralized units.

Initial Recommendations:

- NYSDOT should establish a central location, both physically and organizationally, for the ATMS. A central location would accommodate the planned project, which will be located in a defined area. Any future ATMS projects in Region 4, could also make use of the central location.

### 11. Traffic Operations Center and Traffic Information Center

Traffic Operations Centers typically are responsible for traffic operations and management, as well as the receipt, analysis, and distribution of related facility operations data. Traffic Information Centers gather, process and distribute transportation information but are not involved in the operational control of the transportation system.

Initial Recommendations:

- NYSDOT should consider combining the two functions into one center since the ATMS would be implemented in a defined area. NYSDOT has experience with INFORM which operates as both a TOC and a TIC. The existing county Traffic Operations Center serves as a TOC and a TIC.

### 12. Integration and Coordination

There are significant and important examples of increased integration and coordination among State, multi-state and federal agencies regarding coordination. A full realization of ATMS opportunities over the next several years practically mandates the active involvement of the private sector in a variety of ways.

Initial Recommendations:

- NYSDOT should build on the relationships already established with the other agencies, such as the Monroe County Department of Transportation.

- The Department should take advantage of the fiber optic network that exists in the region. Pure Waters has indicated the availability of portions of its network for traffic information.

- Coordination and integration of public/private joint ventures will require a focus on issues such as rights to intellectual property, control of and revenue from advertising, sharing risks, and basic differences in values and methods of operation.

- Colocation of law enforcement, emergency services and other traffic operators should be a consideration.

### 13. Standards

Several national and regional - as well as state - organizations are addressing standards, but there is no overall coordination of standards development, so far as we know. The INFORM system has installed a fiberoptic network using certain design and installation standards; however these have not become standard throughout the State. Region 10 (Long Island) has an ITS specialist who is developing a standard that may be adopted throughout the state. Region 11 is also undertaking the development of ITS standards and details. Both are still several months away. A set of alternative proposed standards for fiber optic installation have been displayed in Figure V-5 in Chapter V "Regional Communications and Architecture".

## H. USER NEEDS

### 1. User Services

The national ITS program has defined twenty-nine interrelated user services. These user services are defined by their ability to meet the transportation related needs of the users in a given metropolitan area. They are not necessarily related along lines of common technology. The users include the entire spectrum of transportation providers, operators and travelers as well as other fringe groups involved in these transportation services or who may benefit from improved transportation services.

The actual user services are comprised of multiple technological elements and functions. They serve as building blocks that can be combined in many ways for deployment in the Metropolitan Rochester area. The combination of user services can be selected to meet local priorities, needs, institutional frameworks and regional market forces. The user service should be combined in deployable systems and services that will meet the goals for the region. The user services have been grouped into bundles based on those services that are likely to be deployed in a region or corridor scenario. The bundles also typically take into account the commonality of the technological functions for the services. Table II-2 lists the bundles and services and is followed by a brief description of each of these services and bundles.

**TABLE II-2 NATIONAL USER SERVICES**

| Bundle | User Services |
|---|---|
| 1. Travel and Transportation Management | • En-Route Driver Information<br>• Route Guidance<br>• Traveler Services Information<br>• Traffic Control<br>• Incident Management<br>• Emissions Testing and Mitigation |
| 2. Travel Demand Management | • Pre-Trip Travel Information<br>• Ride Matching and Reservation<br>• Demand Management and Operations |
| 3. Public Transportation Operations | • Public Transportation Management<br>• En-Route Transit Information<br>• Personalized Public Transit<br>• Public Travel Security |
| 4. Electronic Payment | • Electronic Payment Services |
| 5. Commercial Vehicle Operations | • Commercial Vehicle Electronic Clearance<br>• Automated Roadside Safety Inspection<br>• On-Board Safety Monitoring<br>• Commercial Vehicle Administrative Processes<br>• Hazardous Material Incident Response<br>• Commercial Fleet Management |
| 6. Emergency Management | • Emergency Notification and Personal Security<br>• Emergency Vehicle Management |
| 7. Advance Vehicle Control and Safety Systems | • Longitudinal Collision Avoidance<br>• Lateral Collision Avoidance<br>• Intersection Collision Avoidance<br>• Vision Enhancement for Crash Avoidance<br>• Safety Readiness<br>• Pre-Crash Restraint Deployment<br>• Automated Highway Systems |

**Travel and Transportation Management**

The Travel and Transportation Management bundle includes six user services that are designed to use advanced systems and technologies to improve the safety and efficiency of the transportation system and to provide motorists with current information about traffic and roadway conditions, as well as traveler services.

- **En-Route Drive Information:** Provides driver advisories and in-vehicle signing for convenience and safety.

- **Route Guidance:** provides travelers with simple instructions on how to best reach their destinations.

- **Travel Services Information:** Provides a business directory, or "yellow pages," of service information.

- **Traffk Control:** Manages the movement of traffic on streets and highways.

- **Incident Management:** Helps public and private organizations quickly identify incidents and implement a response to minimize their effects on traffic.

- **Emissions Testing and Mitigation:** Provides information for monitoring air quality and developing air quality improvement strategies.

**Travel Demand Management**

The Travel Demand Management (TDM) bundle includes three user services that are designed to reduce congestion on the transportation infrastructure by encouraging commuters to use modes other than the single occupant vehicle (SOV), to alter the time and or location of their trip, or to eliminate a trip. In response to congestion and air quality concerns, many cities have already initiated travel demand management activities, and other will be required to do so in response to the mandates of the 1990 Clean Air Amendment.

- **Pre-Trip Travel Information:** Provides information for selecting the best transportation mode, departure time, and route.

- **Ride Matching and Reservation:** Makes a ride sharing easier and more convenient.

- **Demand Management and Operations:** Supports policies and regulations designated to mitigate the environmental and social impacts of traffic congestion.

**Public Transportation Management**

The Public Transportation Management bundle increases four user services that are designed to utilize advanced vehicle electronic systems to provide data which is then used to improve transit service to the pubic.

- **Public Transportation Management:** Automates operations, planning, and management functions of public transit systems.

- **En-Route Transit Information:** Provides information to travelers using public transportation after they begin their trips.

- **Personalized Public Transit:** Provides flexible-route transit vehicles to offer more convenient customer service.

- **Public Travel Security:** Creates a more secure environmental for public transit patrons and operators.

**Electronic Payment**

The Electronic Payment bundle includes one user service, electronic payment services.

- **Electronic Payment Services:** Allow travelers to pay for transportation services electronically.

**Commercial Vehicle Operations**

The Commercial Vehicle Operations bundle increases six user services that are concerned primarily with freight movement and focus in two specific areas, one to improve private sector fleet management, and one to streamline regulatory functions.

- **Commercial Vehicle Electronic Clearance:** Facilitates domestic and international border clearance, minimizing stops.

- **Automated Roadside Safety Inspection:** Facilitates roadside inspections.

- **On-Board Safety Monitoring:** Senses the safety status of a commercial vehicle, cargo and driver.

- **Commercial Vehicle Administrative Processes:** Provides electronic purchasing of credentials and automated mileage and fuel reporting and auditing.

- **Hazardous Materials Incident Response:** Provides immediate description of hazardous materials to emergency responders.

- **Freight Mobility:** Provides communications between drivers, dispatchers, and inter-modal transportation providers.

**Emergency Management**

The Emergency Management bundle includes two user services that relate directly to the detection, modification, and response to emergency and non-emergency incidents which take place on or adjacent to the roadway. The focus is the improvement of the ability of roadside service providers, as well as the ability of police, fire and rescue operations to respond appropriately, thereby saving lives and reducing property damage.

- **Emergency Notification and Personal Security:** Provides immediate notification of an incident and an immediate request for assistance.

- **Emergency Vehicle Management:** Reduces the time it takes for emergency vehicles to respond to an incident.

**Advance Vehicle Safety Systems**

The Advance Vehicle Safety Systems bundle includes seven user services that are related primarily to the safety goals of “ITS”. The implementation of these user services would diminish the number of severity of crashes. The technologies necessary for user services in the Advance Vehicle Safety System bundle are currently in the research and development stages. Because these user services are currently being researched at the national level and are not appropriate for local application during the planning horizon considered in this study, they will not be included in future evaluations for the Cleveland/Lorain project. Definitions are provided here for information only.

- **Longitudinal Collision Avoidance:** Helps prevents head-on, rear-end or backing between vehicles, or between vehicles and other objects or pedestrians.

- **Lateral Collision Avoidance:** Helps prevent collision when vehicles leave their lane or travel.

- **Intersection Collision Avoidance:** Helps prevent collisions at intersections.

- **Vision Enhancement for Collision Avoidance:** Improves the driver’s ability to see the roadway and objects that are on or along the roadway.

- **Safety Readiness:** Provides warnings about the condition of the driver, the vehicles, and the roadway.

- **Pre-Collision Restraint Deployment:** Anticipates an imminent collision and activates passenger safety systems before the collision occurs, or much earlier in the crash event than is currently feasible.

- **Automated Highway Systems:** Provides a fully automated, “hands-off,” operating environment.

**2. Agency Perspective**

At the beginning of this study process, interviews were conducted with over 18 different agencies and authorities that have an interest in the ATMS. The perception of what the ATMS should provide to the stakeholders were noted and summarized. These wants were then correlated with the ITS User Services list. As illustrated earlier, the twenty-nine (29) services are grouped into seven (7) categories; Travel and Transportation Management, Travel Demand Management, Public Transportation Operations, Electronic Payment, Commercial Vehicle Operations and Emergency Management. Advanced Vehicle Control and Safety Systems is not part of this project. Table II-3 summarizes the user service interests of the agencies. The majority of stakeholders were interested in the Travel and Transportation Management aspects such as information and guidance to travelers and incident management. The transit agency and the MPO were very interested in the services provided under Public Transportation Operations such as en-route information and personalized public transit. Once of the objectives of this study is to provide the User Services that are needed in the area based upon analysis of traffic and accident data and the desire to implement an ATMS for the greater Rochester area. Initial equipment locations and resources have been recommended to fulfill these wants and needs.

## TABLE II-3

## SUMMARY OF AGENCY PERCEIVED NEEDS

| CURRENT ITS USER SERVICES | NYSDOT | MCDOT | City Eng'g | City Police | GTC (MPO) | RGRTA (Transit) | NYSTA | State Police | Public Safety-911 | Office of Emerg Prep | County Sheriff | Traffic Reporters | Auto Club | County Info Service | Pure Waters | County Planning | | Consultant Defined Need |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Travel and Transportation Management | | | | | | | | | | | | | | | | | | |
| * En-Route Driver Information | X | | | | X | | X | | X | | X | | | | | | | X |
| * Route Guidance | X | X | | | X | | X | | X | | X | | | | | | | X |
| • Traveler Services Information | X | | | | X | | X | | X | | X | | | | | | | X |
| • Traffic Control | | | | | | | | | | | | | | | | | | X |
| • incident Management | X | X | | | | | X | | | | | | | | | | | X |
| * Emissions Testing and Mitigation | | | | | | | | | | | | | | | | | | |
| Travel Demand Management | | | | | | | | | | | | | | | | | | |
| * Pre-Trip Travel Information | | | | | | | | | | | | | | | | | | X |
| • Ride Matching and Reservation | | | | | X | | | | | | | | | | | | | |
| * Demand Management and Operations | | | | | | | | | | | | | | | | | | |
| Public Transportation Operations | | | | | | | | | | | | | | | | | | |
| * Public Transportation Management | | | | | X | X | | | | | | | | | | | | ? |
| * En-Route Transit Information | | | | | X | X | | | | | | | | | | | | |
| * Personalized Public Transit | | X | | | X | | | | | | | | | | | | | |
| * Public Travel Security | | | | | | X | | | | | | | | | | | | |
| Electronic Payment | | | | | | | | | | | | | | | | | | |
| * Electronic Payment Services | | | | | | X | X | | | | | | | | | | | X |
| Commercial Vehicle Operations | | | | | | | | | | | | | | | | | | |
| * Commercial Vehicle Electronic Clearance | | | | | | | | | | | | | | | | | | X |
| * Automated Roadside Safety Inspection | | | | | | | | | | | | | | | | | | |
| * On-Board Safety Monitoring | | | | | | | | | | | | | | | | | | |
| * Commercial Vehicle Administrative Processes | | | | | | | | | | | | | | | | | | |
| * Hazardous Materials Incident Response | | | | | | | | | | | | | | | | | | X |
| * Commercial Fleet Management | | X | | | | | | | | | | | | | | | | |
| Emergency Management | | | | | | | | | | | | | | | | | | |
| * Emergency Notification and Personal Security | | X | | | | | | | | | | | | | | | | |
| * Emergency Vehicle Management | | X | X | | | | | | X | | | | | | | | | |
| Advanced Vehicle Control | | | | | | | | | | | | | | | | | | |
| * Longitudinal Collision Avoidance | | | | | | | | | | | | | | | | | | |
| * Lateral Collision Avoidance | | | | | | | | | | | | | | | | | | |
| * ~~Intersection Collision Avoidance~~ | | ADVANCED VEHICLE CONTROL | | | | | | | | | | | | | | | | |
| * Vision Enhancement for Crash Avoidance | | NOT PART OF STUDY AT THIS TIME | | | | | | | | | | | | | | | | |
| * Safety Readiness | | | | | | | | | | | | | | | | | | |
| * Pre-Crash Restraint Deployment | | | | | | | | | | | | | | | | | | |
| *Automated Highway Systems | | | | | | | | | | | | | | | | | | X |

# CHAPTER III

# A LONG-TERM VISION STATEMENT

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### III. A LONG-TERM VISION STATEMENT

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# III. A LONG-TERM VISION STATEMENT

## A. What is a Vision?

- A vision is the ability to see the potential in, or necessity of, opportunities right in front of you.
- A vision is not a forecast of the future -- it is creating the future by taking action in the present.

## B. Basic Elements Of The Vision

The Advanced Transportation Management System (ATMS) for the Greater Rochester Area should provide an integrated system for the movement of people and goods on the freeway and arterial highways and transit system. The system should create a seamless link among agencies including New York State Department of Transportation (NYSDOT), Monroe County Department of Transportation (MCDOT), Emergency Medical Services (EMS), law enforcement agencies, Rochester Genesee Regional Transportation Authority (RGRTA), the City of Rochester and private interests. Through current and advanced techniques in surveillance and communication, data on real time traffic flow and weather information will be available to users. Through partnering among agencies use of existing resources can be maximized to improve regional transportation operations.

## C. Goals For The ATMS System In The Rochester Area

**GOAL 1:**

Implement an Advanced Transportation Management System (ATMS) for the Rochester region that strikes a cost-effective balance. In the balance, consider:

- comprehensive geographic coverage
- wide range of technologies
- expressways and arterials
- multi-modal perspective
- eventual 24 hour span of coverage

**as well as:**

- regional benefits
- costs

- funding availability for capital and operational needs.

**GOAL 2:**

Establish an Advanced Traveler Information System (ATIS). It should:

- widely disseminate real-time information
- provide alternate route information during emergencies
- expand NYSDOT's Roadway/Weather Information System (RWIS) and use to provide information to key users and general public

**GOAL 3:**

Continually improve emergency response on the roadways, In doing this:

- provide delineation system on the roadway for use by highway users
- create a Traffic Operation Center that manages traffic flow
- provide a resource for the Incident Commander as part of the Incident Command System
- provide links to the emergency preparedness/county alerting systems
- consider traffic signal pre-emption
- promote regional cooperation among agencies with overlapping responsibilities

**GOAL 4:**

Promote private/public partnership opportunities, such as:

- Emergency service patrols
- Industry
- Education facilities

- Parking facilities
- CB users
- Equipment suppliers
- Communications
- and others

**GOAL 5:**

Promote feedback and ongoing evaluation of the performance of all ATMS/ATIS components.

### D. Highlights Of The Vision

NYSDOT should build, maintain and operate an ATMS on the entire freeway network in the Rochester Area.

- The ATMS should be implemented incrementally, justifying and building public support continually.
- NYSDOT and MCDOT should upgrade and expand the existing traffic control system and integrate it with the ATMS.
- Communications and operations links should be developed between the ATMS and other relevant agencies in the area.
- Private sector participation in the ATMS should be encouraged.
- Joint or partnering activities should be encouraged between participating agencies.
- Incident management activities, including rapid response to incidents, should be implemented.

- RGRTA should upgrade its monitoring activities to include automated vehicle location.
- RGRTA should upgrade, collect and distribute real time information on transit services.
- ATMS information should be used for transportation and transportation-related enforcement activities.
- Training programs for ATMS should be prepared to educate staff of participating agencies.

## E. Detailing The Vision

A vision statement includes a set of indicators of where policy should be developed to further the agreed-upon goals. For the Rochester Area ATMS, the following categories have been explored by the participating agencies:

- Needs of the Relevant Agencies
- Customers and the Benefits Received
- Roles and Responsibilities of the Relevant Agencies
- Other Issues

## F. Needs Of The Relevant Agencies

Agencies which have a direct interest in the establishment of the ATMS have been identified and encouraged to participate in the establishment of the ATMS. These agencies include the following:

- New York State Department of Transportation
- New York State Police
- Monroe County Department of Transportation
- Monroe County Public Safety Department
- Monroe County Emergency Preparedness

- Monroe County Sheriffs Office
- Rochester Genesee Regional Transportation Authority
- Genesee Transportation Council
- City of Rochester Police Department
- City of Rochester Engineering Department

The needs of these agencies were derived from a series of interviews held in 1994, along with discussions since that time. The survey revealed these crucial information needs: real-time traffic conditions, incident status, weather status, tracking transit vehicles, variable message signs (VMS) for motorists, and transit rider information. The technical needs of the agencies include: signal system upgrade, fiber optic communications links, and training. There was an expressed need for one traffic management/information system to: provide strategic and long range direction, foster coordination, avoid duplication, and foster a common language. The interviews revealed an outline of what the system needs: comprehensiveness in geography, technologies and modes, 24 hour access, coverage of all expressways and arterials, incident management that includes all police and liis to emergency preparedness system/county alerting system. Open issues cited in the interviews include: the role of the private sector, funding sources and implementation.

The 1994 interviews were used to form a basic structure for discussion among the agencies. The agencies have met repeatedly to outline an integrated information and data system. For the Rochester ATMS, the following needs and goals have been identified:

**1. Information needs**

Real-time traffic conditions (traffic volumes, classifications, weigh-in-motion, speeds, densities)

- Incident status
- Weather status/roadway conditions
- Tracking transit vehicles
- Variable message signs (VMS) for motorists
- Transit rider information
- Events management

- Park & ride locations and availability
- Downtown parking management

### 2. Technical Needs

- Signal system upgrade
- Fiber optic communications links
- Training

### 3. Integration Of Traffic Management And Other Information Systems Needs

- Provide strategic, long range direction
- Foster coordination
- Avoid duplication -- allow piggybacking
- Foster common language

## G. Customers And The Benefits Received

As the Rochester ATMS is implemented, real benefits will accrue to three distinct sets of customers: (1) End User Customers -- Automobile users, commercial vehicle operators (CVOs) and transit riders; (2) Interim Customers -- Public agencies charged with preserving safety and mobility on the roads; and (3) Regional Residents and Businesses. The manner in which these customers receive benefits is outlined below:

### 1. End User Customers -- Automobile Users, CVOs And Transit Operators And Riders

- Improved traveler information; relocation guidance, incidents, delays, alternative routes and weather problems.
- Greater variety of means of receiving real-time, relevant and useful information.

- Improved travel times and travel time reliability on the roads, due to better incident management and better travel advisories.

- Safer conditions on the road, due to better incident management, delay reduction and better traffic advisories.

- Improved route guidance for transit riders and reassurance of arrival and departure status.

**2. Interim Customers -- Public agencies charged with preserving safety and mobility on the roads.**

- Improved quality and timeliness of information so that it directly enhances their ability to perform their work.

- More efficient use and management of personnel, physical resources and funding.

- Improved credibility of agencies -- better able to meet the needs of their customers, and better able to communicate directly with customers.

- Improved, continually evolving traffic information data base for participating agencies.

- Improved timeliness of service, including on-time transit performance.

- Improved interagency coordination.

**3. Regional Residents and Businesses**

- The economic competitiveness of the region is improved because of improved flow of goods and services .

- Travelers experience a transportation system that is closer to being "seamless" -- among various highway network links, and between highway and transit modes, and which makes fare or toll collection easier for users.

- The quality of life for area residents will be maintained or improved, due to a reduced strain on driving conditions; people feeling that they have more control over their lives as a result of having better information; and added safety to their daily lives.

- Improved sense of community identity - a better 'IMAGE".

- Benefits to commercial vehicle operators and industries may be measurable in terms of reduction in delivery times and increased efficiency of just-in-time deliveries.

- In-vehicle information - both aural and visual - aids individual decision-making before and during travel.

## H. Roles And Responsibilities Of The Relevant Agencies

The following is a description of the future roles and responsibilities of the agencies participating in establishing an ATMS for the Rochester area:

### 1. New York State Department of Transportation

NYSDOT will build maintain and operate an Advanced Transportation Management System (ATMS) /Advanced Traveler Information System (ATIS) on the entire freeway network in the Greater Rochester Area that should consist of the following:

- The NYSDOT's Roadway/Weather Information System (RWIS) should be advanced and incorporated into the ATMS.

- Control of all field equipment on the expressways is with the NYSDOT traffic operations group.

- Equipment, primarily covering the freeway/expressway network, that includes a variable message sign (VMS) system, a traffic detection system, a closed circuit television (CCTV) surveillance system, and a highway advisory radio system. Additionally, provisions should be made to incorporate a traveler information kiosk system in key generators in the area and to offer a highway advisory telephone (HAT), VMS, and an electronic bulletin board system to the citizens and businesses in the area.

- Other systems, not presently justified by the existing or future traffic conditions, may include a freeway/expressway ramp metering system and a high occupancy vehicle (HOV) network. These should be continually evaluated over time.

- The Canal Lift Bridges should be included as part of the ATMS to monitor the status of the bridges. This information will be useful in determining diversionary routes for traffic during incidents.

- The status of the At-Grade Railroad Crossings should be incorporated as part of the ATMS. This information will also be useful when choosing alternate routes during times of incidents.

- The New York State Thruway Authority, along with toll authorities of adjoining states in the Inter Agency Group (IAG) is advancing the use of EZPass This electronic toll and traffic management (ETTM) system utilizes a transponder for electronic toll collection (ETC). With transponder-equipped vehicles used as probes, individual vehicle travel times can be measured between instrumented reader stations. With sufficient penetration, this direct measurement may be a better indication of congestion along expressways, freeways and major arterials, than presently available methods of detection.

- Additional traffic signals, not already on the Monroe County DOT's UTCS (Urban Traffic Control System)/Zone Monitor systems, should be accommodated so the signal systems can monitor traffic and be made part of the overall ATMS.

- Freeway service patrols should be incorporated into the overall traffic and incident management system to help in the removal of disabled vehicles associated with minor incidents.

- These ATMS/ATIS systems, described above, should be operated and maintained by the NYSDOT, either directly through increased staffing and training or contracted to an outside company or agency.

- The traffic operations staff should be a totally dedicated single function unit coming under the Traffic and Safety Section of the NYSDOT supported by maintenance staff.

- NYSDOT should have sole control of the operations of the freeway/expressway systems.

- The NYSDOT and MCDOT traffic signal systems should be compatible to allow for the option of "joint control" should there be a need for joint operations of the traffic control system in the future.

**2. Monroe County Department of Transportation**

MCDOT should upgrade the UTCS and Zone Monitor systems to a system that can be totally traffic responsive and would have integration capabilities with a large regional system on a PC based multi-tasking platform with a geographic information system (GIS) based computerized graphical map display (compatible with other agencies).

- The upgraded MCDOT system should be interfaced with the freeway/expressway system and with the State's traffic control system using a common database and reactive to the same conditions. The system must be capable of including traffic signals at the ramp termini with end of queue detectors on the ramps for ramp metering.

- The remainder of the county and city signals, not yet included in the county system, should be incorporated into the upgraded PC based system; continuing with the MCDOT plan of a signal system with ultimately 600 traffic signals or more.

- The Stutson Street Lift Bridge should be included as part of the ATMS to monitor the status of the bridge.

- MCDOT should have primary control of operations of the signal system.

- The freeway management system and traffic signal system of the NYSDOT and the signal system of Monroe County DOT should operate under a networked, distributed operating system; ultimately housed in the same operations center.

- MCDOT and NYSDOT should have dual control of any CCTV cameras on the arterial network, while NYSDOT should retain primary control of those cameras on the expressways. Communications should be established for multiple agencies to view any CCTV camera image at any time.

- MCDOT and NYSDOT should implement signal pre-emption for emergency and transit vehicles on the arterial system.

**3. New York State Police (Greater Rochester Interstate Patrol)**

The NYS Police should be located in the traffic operations center with NYSDOT and MCDOT. An officer, with the authority to make decisions with regard to traffic control and safety, should be located at a traffic operations console for command and control for police operations.

- NYS Police should have no direct control of the operations of the freeway/expressway or traffic signal equipment.

- The police desk should be able to view the CCTV camera images and should be able to request selection and movement of the CCTV cameras.

- The police desk should be able to view the freeway and arterial status displays.

### 4. New York State Thruway Authority (NYSTA)

- The NYSTA should have dial-up remote access to the ATMS information and status display.
- The NYSTA should have no control of the equipment.
- The EZPass ETTM system should be implemented in the Rochester area and should be used as a means of detection of incidents in the southern area of the system.

### 5. Rochester-Genesee Regional Transportation Authority

A communications link should be established between the TOC and the RGRTA dispatch center for direct access to the recurring and nonrecurring traffic information. RGRTA should consider locating one operations person in the traffic operations center for two purposes; 1) to be the contact at the TOC for RGRTA's automatic vehicle location (AVL) system information, and 2) to contact the RGRTA dispatch center with traffic flow information from the ATMS.

- The RGRTA representative should have no control of the operations system equipment, but should be able to request information.
- The AVL system displays would be included in the ATMS PC based multi-tasking environment and be used as a primary or secondary source of traffic low information.

### 6. 911 Center/Office of Emergency Preparedness

- The 911 Center should have a two-way communications link with the TOC.
- The 911 Center can serve as a primary detection source from cellular 911 calls. These calls can provide direction on which CCTV cameras to view or in general where an incident has occurred.
- The Emergency Operations Center (EOC) should have a two-way communications link with the TOC.

7. **City of Rochester Engineering Bureau / Department of Environmental Services Dispatch**

- A two-way communications link from the ATMS to the City of Rochester should be established. This could include such agencies as Engineering, Department of Environmental Services, Municipal Parking, Police and others.

- Information on the freeway and arterial network should be available to the appropriate City of Rochester agency, especially during special events. Ultimately, control of all field equipment is with the NYSDOT traffic operations group.

8. **Maintenance Agreements**

- A flexible agreement between NYSDOT and MCDOT for the maintenance of the signals should be expanded. The agreement needs to be flexible to account for any changes that might occur in the jurisdiction of certain traffic signal systems.

- An agreement between NYSDOT and MCDOT should be developed for maintenance of the additional traffic signals that are brought on-line.

- Consideration should be given to establishing central dispatching for all traffic signals to simplify complaint reporting by the public.

- Maintenance agreements should be formalized and written.

9. **Operational Agreements**

- NYSDOT would operate the ramp metering signals.

- NYSDOT and MCDOT should determine which traffic signal systems will be within which jurisdiction. This could be determined on a case-by-case basis. Certain systems could become part of the state system others could remain within the county system, and some individual intersections could change jurisdictions.

- The NYSDOT and MCDOT traffic signal systems should be as compatible as possible should joint operations of the traffic control system be necessary and/or desirable in the future.

- The existing agreement between MCDOT and NYSDOT should be expanded to cover the additional traffic signals.

### 10. Private Sector Involvement

- Wherever possible, the private sector should be involved in developing and expanding the ATMS.
- Private sector should include, but not be limited to, universities/colleges, manufacturing and service companies, the broadcast and print media, communications and entertainment companies, etc.
- The areas where the private sector should participate include freeway service patrols, information kiosks, new products testing, area wide communications network development, etc.
- Information should be sent to traffic reporting systems.

## I. Issues In Implementation

### 1. Maintenance Issues

Agencies participating in the ATMS should develop clear guidelines on the maintenance of the elements of the system. The following are beginning elements of assigning responsibilities for maintenance:

- A flexible agreement between NYSDOT and MCDOT for the maintenance of the signals should be expanded. The agreement needs to be flexible to account for any changes that might occur in the jurisdiction of certain traffic signal systems.
- New traffic signals added to the MCDOT system should be maintained as part of an agreement between NYSDOT and MCDOT.
- Maintenance agreements should be formalized and written, whether the work is done in-house at public agencies or by contract with private firms.
- Maintenance of other ATMS equipment should be formalized and written, whether the work is done in-house at public agencies or by contract with private firms.
- Space at the TOC should be reserved for maintaining, testing and troubleshooting; either on-site or off-site storage should be provided.

### 2. Operations Issues

Agencies participating in the ATMS should also develop clear guidelines on the operations of the ATMS system. These responsibilities should grow from the following initial principles of operation including:

- NYSDOT and MCDOT should determine which traffic signal systems will be within which jurisdiction. This could be determined on a case-by-case basis. Certain systems could become part of the state system, others could remain within the county system, and some individual intersections could change jurisdictions.

- Any new ramp metering signals should be NYSDOT's responsibility.

### 3. Open Issues

There are several issues that will continue to be explored and which will be continually updated as new information becomes available:

- Roles for the private sector
- Funding sources: agencies, balance, availability
- Full implementation
- Policy on CCTV use -- Traffic purposes
- "Open architecture" for in-vehicle navigation systems
- Modify to incorporate new technologies

# CHAPTERIV

# STRATEGIES EVALUATION

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# IV. STRATEGIES EVALUATION

## A. Introduction

This chapter presents summaries of each of the incident management options identified by the project team during the state-of-the-art review. The incident management measures are divided into five sections, each of which corresponds to one of the basic categories of incident management: incident detection and verification, incident response, incident clearance, site management, and motorist information. Also included are brief descriptions of each incident management measure that might provide improvements to that aspect of incident management.

## B. Incident Management

The heart of an incident management program is the surveillance sub-system. This sub-system supports three different types of functions: counting and monitoring individual vehicles; analyzing vehicle flow information for incident and subsequent congestion detection; and providing visual images for confirmation, interpretation and analysis.

Various algorithms have been developed to detect incidents. Most algorithms compare traffic parameters such as vehicle occupancy (the amount of time a vehicle's presence is detected at a particular point on the roadway), speed or volume between adjacent detector stations. The California class of algorithms which do this type of comparison have been used with reasonable success for many years. The McMaster algorithm has been developed to operate with single station detection where specific characteristics of the measured speed, occupancy and volume are used to indicate the existence of congestion. The determination of whether this congestion results from an incident or excess volume also needs to be performed. This determination is not necessary if the highway has excess capacity and is not subject to recurring congestion.

Incident detection and management relies on accurate real-time traffic flow data. A hybrid of automated detection, with computers monitoring detector locations, and human observation using closed circuit television is commonly used for Advanced Traffic Management Systems (ATMS). Although each of the sub-systems can work independently, automated detection and visual verification are functions that complement one another. The best performance results from an automated detection system that calls upon a human observer to view a possible incident and determine an appropriate response. As more progress is made in ITS technologies, including image processing, artificial intelligence, and expert systems technology, it is inevitable that computer systems will augment the capabilities of the human observer.

Transmission of information to the motorist is an integral part of an incident management system. This provides the mechanism to alert the motorist of problems ahead, so that an alternate route can be taken. The most commonly used technology installed along the road is the Variable Message Sign (VMS). Another commonly used method to communicate with motorists is Highway Advisory Radio (HAR). Effectiveness of HAR is improved when signs alert drivers to new messages with flashing lights. Dial-in telephone services have been implemented in various forms, and Highway Advisory Telephone (HAT) is becoming common. An innovative traveler interface has been utilized by some systems involving public kiosks and terminals. Units might be located at convenient locations such as hotels, shopping malls and major workplaces. Direct information about highway congestion and travel time can be provided for user designated routes. General information about area highways might be displayed without specific requests. Cellular telephones are often used to inquire about roadway congestion and to report incidents. Commercial radio and television stations broadcast periodic traffic reports in many metropolitan areas, and studies have shown that this is presently the most commonly used source of traffic information.

**A Traffic Operations Center (TOC)** is a central information processing, dispatch and control site for the management of a transportation system. In a multi-jurisdictional situation, it is advisable to develop one overall TOC, providing better service than several uncoordinated centers. Since the primary function of a TOC is information sharing, it is best to link its operations with existing agencies. Ideally, it would include all of the decision makers involved in a major incident, especially the Office of Emergency Preparedness command center.

Computer equipment and software located at the traffic operations center (TOC) collects and centralizes all the various types of data and information generated by the surveillance sub-system. It also provides a control interface for motorist information sub-systems. Modern computer technology has reduced the size and cost of the computer hardware. However, the complexity of the software continues to increase as the functional demands for graphical user interfaces, and other state-of-the-art features, are included in the overall computer system.

### 1. Potential Improvement Options for Incident Management

Potential improvement options for a transportation management system range from capital and operating expenditures to institutional and jurisdictional measures. A wide variety of options are used successfully elsewhere. Although all may not be applicable to the Rochester ATMS, it is useful to review them prior to selecting a recommended system for the Metropolitan Rochester area.

Potential system components can be categorized by the incident management process: detection and verification, response, site management, clearance, and traveler/motorist information. This section provides information on potential options considered for the Metropolitan Rochester area.

### a. Detection and Verification Options

The sooner an incident can be detected and verified on the primary route, the less impact the incident will have on the normal flow of traffic The following options for detection and verification may be used to bring an incident to the attention of the responsible agencies or authorities:

- **Dedicated Freeway/Service Patrols** are important in areas where timely incident detection and response is particularly critical or where other electronic detection equipment is not available. Many minor accidents and incidents can be cleared with the patrol vehicle, eliminating the cost and delayed response of tow trucks. The supplies carried by service patrols are sufficient to clear many incidents related to vehicle breakdown. In addition, push bumpers mounted on the service vehicle allow for quick clearance of small accidents. Also, once the patrol stops at an incident scene, its detection capability on the rest of the primary routes is eliminated. Several private companies have successful organized service patrols. They train the personnel, equip the vehicles, and operate the service. Other freeway/service patrols are operated in a similar manner by transportation agencies.

- **Motorist Aid Call Boxes/Telephones** are appropriate in isolated areas, where detection times are lengthy. Reporting can be done 24 hours a day directly to the responding agency.

- **Incident Reporting with Cellular Telephones** is similar to a "911" system, but uses a different phone number. In many cases these systems can be monitored by existing dispatch staff, requiring no special training. Motorists usually provide timely information about a particular incident. However, the use of the system is limited to cellular telephone owners, the workload of the dispatcher is increased dramatically, and roadside signs are required to inform motorists of the system. Capital operating and maintenance costs are relatively low and the benefits are generally high. To increase these benefits, cellular telephones should be distributed to Monroe County and New York State DOT personnel who frequently use the freeways during commuting hours in return for calls at regular intervals to track travel speeds and report incidents. This technique has been successful in the Boston area.

- **Citizens' Band (CB) Radio Monitoring** is similar to the cellular telephone system. These communications, over a dedicated CB channel, can be monitored by service patrol vehicles on patrol as well as by existing police dispatchers. Multiple transmissions will help to verify and locate the incident. Much of this potential is focused on the truck driver. As with the cellular system there will be an increased workload for the dispatcher, and roadside signs are necessary to inform the CB user of the system.

- **Volunteer Watch** involves citizen observation of the freeway from vantage points in high incident areas or directly in vehicles calling in observations on a periodic time basis. The advantages of a volunteer watch include visual verification and initial assessment of the incident. Disadvantages might include lack of available volunteers for a particular high incident area, as well as the need for training or instruction to acquire reliable information. A successful informal program has been established in conjunction with the northern New Jersey Freeway Management System.

- **Ties with Transit/Taxi Companies** can take advantage of vehicles already on the road with two-way radio communications. This method of detection would be expanded to cover the entire city street system in addition to local freeways. Travel times and roadway conditions could be determined from Rochester-Genesee Regional Transportation Authority Automatic Vehicle Location/Automatic Vehicle Monitoring equipment, which will be installed on some of their fleet by the end of 1995. This method of detection and verification requires very little training. Incident data would be reported to the transit or taxi dispatcher and relayed to the traffic operations center. The dispatcher would then relay the information to the appropriate agency. This improves the efficiency of the transit/taxi operations in that the dispatcher shares the information with the other vehicle operators. This is a very low cost solution and, if properly executed, would produce significant benefits.

- **Aircraft Patrols** are currently being used in the Metropolitan Rochester area for commercial radio traffic updates. This method has potential for monitoring shifts in traffic to diversion routes and visually analyzing traffic distributions. One disadvantage of patrols is the high cost, which typically limits patrols to peak periods. Also, weather conditions and “lake effects” can reduce flying times. The aircraft patrol would provide timely information by calling directly into the traffic operations center. Data compiled at the TOC would be made available to the operators of the aircraft patrols and as well as to operators of vehicle probes providing information to the TOC. Since these types of commercial patrols are not funded by the transportation agency or police, the exchange of information can result in a high return.

- **Electronic Detection** includes inductance loops, radar detection units, infrared detection units, microwave detection units, and video imaging detection systems (VIDS). These systems vary in cost, accuracy, and proven reliability. Traffic flow information collected by these devices is sent through a communications link (leased telephone lines, twisted pair wire, or fiber optic cable) from the detector’s roadside processor to a central computer with incident detection software. The advantages of electronic systems include 24-hour operation and traffic data collection capability. Some disadvantages are high initial cost, false alarms, and potentially high maintenance costs.

- **Roadway / Weather Information Systems (RWIS)** such as that currently in use, can detect weather and pavement conditions. This could be considered a pro-active approach to incident detection since it does not detect vehicular incidents but rather one of the causes of incidents. Expansion and enhancement of the system would improve detection capabilities. Possible areas of enhancement include:

  Performing specialized analysis of the data, which when combined with wider area weather information, can be provided to a service organization staffed by professional meteorologists. This additional analysis provides forecasts and interpretations of conditions that can enhance the management of the area roadways. Nearby states that have installed roadway weather monitoring systems include: Pennsylvania, Ohio, Virginia, Indiana, Illinois, Tennessee and the District of Columbia. Many agencies on the East Coast and northern mid-west have reported beneficial operation from use of weather monitoring systems.

  Improve the communications between the remote sensor stations and the maintenance facilities. The method of communication to be used should be selected on the basis of availability, reliability, and cost. The obvious choices include: leased line, standard telephone, cellular telephone, packet radio, satellite communications, and owned communications infrastructure that includes existing radio and cable facilities. Data transfer requirements are only a few hundred bytes per inquiry, so standard communication rates and low cost modems can be utilized.

  Roadway weather information is also useful to monitor subsurface conditions that may be cause to restrict the travel of heavy vehicles. Major damage to roadway surfaces can occur during the cycles when the sub-surface can take on a plastic consistency. Application of pavement treatments can also be performed during seasons when conditions are variable, provided that roadway surface temperatures can be expected to remain within acceptable range.

  Increasing the number of sites to other areas of the county.

  **Closed-circuit Television (CCTV)** provides quick incident assessment, and promotes proper response to incidents. This system also provides a method to record selected incident response activities for later review. Full system coverage of the freeway would require approximately one camera per mile plus additional cameras at interchanges. Manually monitoring these cameras is ineffective. Cameras can be linked directly to detection subsystems to automatically activate an alarm and call up the appropriate camera.

### b. Response Time Improvement Options

Identifying the proper response to an incident and getting the appropriate equipment to the scene as quickly as possible are the keys to efficient and reduced response times. Interagency communications and cooperation are very important where fast response is needed.

- **Personnel, Equipment, and Materials Resource Lists** provide information on who should respond in each particular segment. Police, fire, EMS, transportation, media, and private agency contacts as well as the method of communication would be specified. Radio channels and telephone numbers should be clearly identified. This list would be distributed to the appropriate responding agency personnel. The same type of list would be compiled for equipment and materials in the area. These relatively inexpensive tools will save time and effort in the event of an incident. These lists may already exist with the Office of Emergency Preparedness, but may need to be tailored more toward transportation related incidents.

- **Dedicated Freeway/Service Patrols -** see Section a.

- **Personnel Training Programs** emphasize the coordination aspect of incident response, making each agency aware of the other agencies' needs and requirements. A demonstrated willingness to participate and cooperate is required by all agencies if the incident response team approach is to be successful.

- **Revised Tow Truck/Removal Crane Contracts** may be established with private firms to reduce the response times at frequent incident locations, and to allow immediate use of necessary equipment. These contracts eliminate the question of who to call when specific equipment is required. Agency owned tow trucks are typically costly to purchase and operate. Private contracts offer financial incentives for the tow truck company to clear the freeway as quickly and safely as possible. The agreements developed by Fairfax County, Virginia are one example of successfully applying this option. Heavy duty wreckers stationed at key points allow for the quick removal of major equipment, debris, and spills. Generally these are warranted for short sections (usually bridges and tunnels) with high truck volumes.

- **Improved Interagency Radio Communication** may require the purchase of compatible two-way radio equipment and the use of a common nomenclature or terminology. This would improve site management and provide better information to the respondent personnel. However, it may not be feasible for all agencies to participate and to invest in new equipment. Costs vary depending on specific equipment needs. Command posts, such as mobile command centers may be needed at incidents where two or more agencies are involved. This facilitates communications and saves time by reducing repetition of commands.

- **Ordinances Governing Travel on Shoulders** will be possible only in areas where shoulder widths are wide enough for emergency equipment. In order for emergency vehicles to reach the scene of an accident it may be necessary for vehicles to travel on the shoulder. In some situations during incidents, travel by the public on shoulders to circumvent the incident may be necessary. It would be a wise decision to incorporate sufficient shoulder widths in any redesign projects.

- **Emergency Vehicle Access,** such as movable barriers and U-turns at key locations along the freeway, reduce response times for emergency vehicles. These techniques are useful for response vehicles when one direction of the highway is completely blocked and access is only possible by approaching the scene contra-flow to the travel direction. However, unauthorized **motorists** may be tempted to use these U-turn facilities, and movable barriers are expensive.

- **Diversion Route Planning** is useful when the capacity of the primary route is reduced by an incident. It is important to plan routes that avoid low overpasses or severe turns. Either temporary or permanent signing is required at junctions and along the route to reduce confusion and provide for smooth traffic flow. Use of VMS and/or HAR to inform motorists of the alternate route is very effective.

- **Diversion Route Management** is needed to adjust traffic signal timings to accommodate additional traffic flow after a diversion plan is requested. The computerized arterial traffic signal system should incorporate a feature to automatically recommend and/or implement an incident response timing plan. Diversion route management techniques can also be used to locate underutilized alternate routes and redirect traffic to them on a real-time basis.

- **Equipment Storage Sites** would reduce response times by providing special removal equipment at high incident locations. Costs are minimal if this space already exists, but it may be difficult to find additional space at some high incident areas. Large equipment to be stored might include wreckers, sand trucks, and other large vehicles. Smaller items include cones, signs, flares, portable barriers, and other equipment for traffic control.

- **Administrative Traffic Management Teams** include officials from transportation, police, fire, and rescue agencies, such as the Committee. This strategy requires a willingness to cooperate by all participating agencies. The intent is to provide a forum for discussion of unresolved incident management issues, preplanning for response, and improved communications.

- **Public Education Programs** inform motorists of their rights and responsibilities when they are involved in a traffic accident. Motorists may be permitted to move their vehicles from the scene of an accident according to New York state law, but may not do so. Most are reluctant to do so in any case because of misconceptions regarding the legality or liability of the action.

- **Traffic Operations Center-** see Section a.

- **Closely Spaced Reference Markers,** as well as other landmark and directional markers, help in locating incidents. These markers aid cellular telephone callers in reporting incidents, and provide improved record keeping for analysis of incidents. The markers would be located on the center median barrier to enhance visibility and reduce costs. For ramps and collector-distributor roadways, special numbering, colors, and/or patterns would be necessary, due to the potential for confusion. Utility poles might also be designated with markers to identify locations along the freeway. These markers might be placed every 1/10 of a mile or every 2/10 of a kilometer.

### c. Site Management Options

Incident clearance can become more effective if the site management techniques are well executed. Coordination of personnel and control of traffic help to reduce the likelihood of secondary accidents.

- **Incident Response Teams** would be comprised of personnel from various agencies. These teams would be trained to handle unusual incidents and would be familiar with one another. Incident response teams might improve site management and clearance efforts in special circumstances, but they are likely to be ineffective if not properly trained and equipped.

- **Personnel Training Programs** - see Section b.

- **Improved Interagency Radio Communications** - see Section b.

- **Properly Defined Traffic Control Techniques** are standard guidelines for lane closure which are identified and agreed to in advance. The guidelines should be consistent with FHWA's Manual on Uniform Traffic Control Devices and any superseding state guidance. This action requires cooperation among agencies. The incident management team would provide an appropriate forum for this activity.

- **Properly Defined Parking for Emergency Response Vehicles** is a technique of identifying in advance the appropriate place at an incident site for placement of response vehicles. This placement depends on the nature of the incident. As with the traffic control techniques, this is a cooperative action, In a related policy, Seattle recommends that emergency vehicles be positioned so as to close no more travel lanes than those already blocked by the incident.

- **Flashing Lights Policy** would be considered to reduce distraction to non-involved motorists. Flashing lights may not be required when the respondent vehicles are on the shoulders. The drawback is that the response team members may not feel as safe. Some field testing may be necessary to get reactions from incident response team members and the public, and some legislative work may need to be done.

- **Administrative Traffic Management** Team - see Section b.

- **Traffk Operations Center -** see Section a.

- **Diversion Route Planning -** see Section b.

- **An Incident Response Manual** would be developed to increase the efficiency at the incident site. Input by all involved agencies is required to produce a document that accurately defines all procedures for site management. It should be specific to the facility, roadway or corridor it deals with. Frequent updating and training is also required.

**d. Clearance Time Reduction Options**

- **Policy Requiring Fast Removal of Vehicles** is a low cost method of returning the roadway to normal operating conditions where shoulders exist or where there is adequate space for a holding area. Liability may be an issue if damage to the disabled vehicle occurs. Generally, however, this policy has no cost to the transportation agencies, and would make police and other response personnel available to perform other more important duties. This is a low cost, high benefit solution which reduces the number of responses, but it may be difficult to change motorists' behavior.

- **Accident Investigation Sites** allow operable vehicles involved in non-injury accidents to be removed from the travel lanes immediately. In many situations, secondary accidents occur due to blockage of travel lanes. With the use of off-road or out-of-sight Accident Investigation Sites, secondary accidents are less likely. Accident Investigation Sites are used to interview those involved, fill out police reports, and make necessary telephone calls. The area should be flat and well lighted with a telephone or call box. Finding an appropriate location may be difficult, and site preparation, signing, and publicity will require a degree of investment. Clearly displayed signs along the freeway are needed to inform motorists of accident investigation sites.

- **Dedicated Freeway/Service Patrols -** see Section a.

- **Push Bumpers** can be added to the tow trucks, emergency service patrols and police vehicles. They are especially beneficial for quick clearance along elevated roadways and sections with inadequate shoulder widths.

- **Responsive Traffic Control Systems,** such as the computerized traffic signal system currently in use, will aid in diversion route management. When diversions become necessary, the NYSDOT traffic operations staff will notify Monroe County DOT traffic operations staff to implement a pre-determined traffic signal timing plan which will provide more capacity to the diversion route during the duration of the incident. Also, NYSDOT will soon be obtaining a statewide license for closed-loop signal system software which could offer traffic responsive signal control.

- **Ordinances Governing Travel on Shoulders -** see Section b.
- **Emergency Vehicle Access -** see Section b.
- **Diversion Route Planning** - see Section b.
- **Incident Response Teams -** see Section c.
- **Personnel Training Programs -** see Section b.
- **Incident Response Manual -** see Section c.
- **Administrative Traffic Management Teams -** see Section b.
- **Public Education Program -** see Section b.
- **Total Station Accident Investigation Equipment** is a combination of electronic surveying and distance measuring devices developed exclusively for the investigation of accidents. This type of equipment reduces delays, personnel requirements and exposure of personnel to traflic hazards since accident investigations can be carried out more quickly.

**e. Traveler/Motorist Information Options**

- **Highway Advisory Radio (HAR)** is a powerful instrument to share information with travelers in their automobiles, Information regarding planned lane closures due to construction or maintenance is broadcast repeatedly over the HAR. Advanced warning to motorists of lane closure schedules, incidents, or special events will help to reduce the traffic demand at the closure, and may reduce the number of accidents in the area. HAR transmitters would be needed to provide coverage for motorists in and around the Metropolitan Rochester area to inform motorist prior to the beginning of their trip.
- **Variable Message Signs** (VMS) are used alone and in conjunction with HAR to inform motorists of planned lane closures, incidents and special events. Truck mounted or trailer mounted VMS can be very effective in incident management. These can be located and moved in response to a major long term incident.
- **Traffic Operations Center -** see Section a.
- **Commercial Radio and Television Broadcasts** are good sources of information for the traveling public in most cases. Commercial radio is a well known source for traffic information in the Metropolitan Rochester area. In some communities,

commercial broadcasts have been known to provide outdated or incorrect information.

- **Kiosks,** for special traffic generators such as shopping malls and large employment buildings, could be used to inform motorists of traffic conditions. On-screen graphics and text could convey accident and incident information, travel times, or even provide suggestions for the best route to a motorist's destination.

  **PC/Modem** systems could be used to tap into the Traffic Operations Center's computer from home or work. A telephone hotline would be established so that travelers could call in for conditions on the primary route. A caller would enter the route number, the entry and exit interchange number on his key pad and the direction of travel. The computer would dispatch information to the caller on current roadway conditions. Private sector firms could become involved in establishing this service.

- **Roadway Weather Information Systems (RWIS)** - see Section a.

**2. Selected Potential Improvement Recommendations**

The following are selected potential options for each of the five basic categories of incident management. These selections are based 'upon discussions at various meetings with the Technical Advisory Committee and the Incident Management Task Force.

**a. Selected Potential Detection and Verification Recommendations**

**Near-Term/Short-Term:**

**Incident Reporting with Cellular Telephones** using the already established 911 number which is a direct line to the Monroe County 911 Center. The 911 operators and dispatchers would continue to be the link to the emergency response personnel. The 911 number for cellular telephone users should be publicized by installing roadside signs, insert advertisement in print media, and incorporating flyers in with the cellular telephone bills.

**Roadway Weather Information Systems (RWIS)** should be expanded and upgraded to take advantage of the latest industry advancements. Cost effective communications improvements or additions could be made. A good candidate for communications of RWIS data is cellular packet radio. Packet radio was developed for the transmission of data. This communication technology is not likely to be in heavy use during severe weather emergencies. Cellular telephone systems, on the other hand, could be overloaded when they are needed the most. At present, each application to be used on packet radio requires certification by the carrier. This could involve some costly software modifications to adapt to the packet protocol. The use of packet radio should provide a rapidly implemented reliable and cost effective means of data communication to areas where wire lines may be difficult to install.

**Long Term:**

**Closed Circuit Television Cameras** placed at approximately one-mile intervals in areas of high incident frequency is a long term recommendation for verification of incidents. The CCTV cameras should be utilized to verify incidents that are called in on the *TIP lines or other sources such as electronic detection systems.

**Electronic Detection Devices** placed at approximately half-mile intervals in areas of high incident frequency and high traffic volume should be used to detect slowing or stopping of traffic and should turn on an alarm or CCTV camera to verify the incident.

**b. Selected Response Time Improvement Recommendations**

**Near-Term/Short-Term:**

**Personnel, Equipment and Materials Resource Lists** should be developed and kept current with the incident management forces such as police, fire and emergency medical departments. A computerized bulletin board should be developed to access the list by all the participants. This should also facilitate keeping the list current. Telephone numbers should be keep current along with names of personnel.

**Tow Truck/Removal Crane Contracts** should be established to facilitate quick removal of disable vehicles, especially heavy truck, from sensitive areas such as the I-490/I-590 interchange. Positioning of removal vehicles close to high incident areas should reduce the response time significantly.

Similarly, **Equipment Storage Sites** reduces response times by locating special equipment close to high incident areas. DOT maintenance yards or other state owned property near the freeway on-ramps are key locations.

**Closely Spaced Reference Markers,** landmark signing and directional signs placed on overpasses and townlines help to provide better location information. The more markers, the easier it is for motorists to locate disabled vehicles using cellular call-in systems.

**C. Selected Site Management Recommendations**

**Near-Term/Short-Term:**

**Properly Defined Traffic Control Techniques and Properly Defined Parking for Emergency Response Vehicles** should be significant sections of **an Incident Response Manual** which in turn saves time and improves site management for incidents. The manual should be developed by the **Incident Response Teams** and included in the **Personnel Training Program.**

**d. Selected Clearance Time Reduction Recommendations**

**Near-Term/Short-Term:**

**Push Bumpers** are already equipped on State Police cruisers that patrol the I-490 inner loop, I-590 and I-390 within Rochester City limits. Additional vehicles should be equipped to help facilitate quick removal of non-injury accidents.

**Total Station Accident Investigation Equipment** should be purchased by police department to expedite the measurement process at the accident scene. This not only saves time but reduces the amount of exposure to secondary accidents by distracted motorists.

**Long Term:**

**Responsive Traffic Control Systems** should necessitate the integration of the Monroe County UTCS and Zone Monitor system for the arterials with the ATMS for the freeways. Key expressway interchanges that are currently running as isolated intersections should be placed under central control. In addition, the primary arterial routes and diversion routes should receive priority in any conversions from the existing UTCS and Zone Monitor system to a new system. This integration should facilitate the use of the arterials, that are included in the UTCS and Zone Monitor system as alternate routes during lane closing incidents of long duration.

**Accident Investigation Sites** should be established for minor accidents when vehicles are able to be moved. Areas on local streets such as on-street parking spaces should be allocated for Accident Investigation Sites. Utilizing local streets keeps the freeways free flowing and usually provides telephones nearby.

**e. Selected Traveler/Motorist Information Recommendations**

**Near-Term/Short-Term:**

**Commercial Radio and Television Broadcasts** are already part of the traffic reporting process in Rochester. Attention to the timeliness of the reports is important. Outdated information or misinformation could hurt the reputation of the reporting service. Tip lines could be set up with mobile telephone operators to enhance the reporting of incidents and congestion. Calls could be made directly to the radio or television stations. However, close attention to these calls is necessary to screen out false calls and misinformed calls.

**Long Term:**

**PC/Modem Systems** should be subscribed to by the public and tapping into the graphical display of the ATMS for the freeways and the integrated traffic management systems of the arterials, similar to the INFORM system in Long Island. Major employers and individuals should pay for access to the system with a monthly subscription.

Kiosks should be deployed at major traffic generating sites such as shopping malls, large office complexes and colleges and universities. Who pays for the communications feed to these kiosks would need to be negotiated with the owner of the property and the NYSDOT. Interviews with the University Presidents organizations revealed an interest on their part. The Chamber of Commerce all expressed interest in traveler information kiosks.

## C. Congestion Management

Congestion management in the Greater Rochester Area involves various agencies and efforts. Currently, there are a number of transportation demand management (TDM) districts being organized by GTC, along with GTC's continued promotion of increased car-pooling and van-pooling. Public transit is encouraged through the continued promotion of added park and ride facilities.

Monroe County's UTCS and Zone Monitor systems monitor the roadway system for congested areas. Manually, signal timings are continually adjusted to alleviate these congested areas in the system. System sensors are used to identify and quantify recurring congestion locations and to evaluate the effectiveness of timing plan revisions. Also, various transportation agencies such as the Genesee Transportation Council, NYSDOT and MCDOT continually evaluate the Greater Rochester Area to identify emerging congestion areas. In addition to efforts by transportation agencies, large employers, such as Kodak, have aided in congestion management by staggering work hours thereby dispersing peak hour traflic. These employers have also been involved in promoting increased use of public transit as well as car-pooling and van-pooling.

To manage congestion related to special events, such as Tall Ships or the Empire Games, special groups and organization are formed on an as needed basis. Major construction projects also form special groups for congestion management.

Several techniques exist for decreasing congestion on freeways. Ramp metering can be used to divert traffic that utilizes the freeway for short trips and can also smooth out the flow of traffic on the freeway. High Occupancy Vehicle (HOV) lanes can be implemented to move more people in fewer vehicles by providing exclusive lanes on the mainline and queue by-pass lanes at congested interchanges especially from freeway to freeway. Predictive algorithms can be used to balance traffic between freeways and alternate arterials within a corridor.

Ramp metering requires analysis and determination of congested sections of freeways. A threshold of volume to capacity ratios (V/C) will be determined to identify congested segments. Congested segments will be linked together to form a larger section. The ramps within this section as well as several ramps upstream of the beginning of the section will be field checked to determine the length of queued vehicles that could be stored. To properly deploy ramp metering it may be necessary to reconstruct those ramps which have very little storage length. Detectors on the ramps for queues spilling back onto local streets as well as detectors at the stop bars along with signal heads, and the controller and cabinet are the necessary equipment. In some cases, detection in the right lane of the freeway upstream of the ramp is used to identify available gaps in the mainline .

High Occupancy Vehicle (HOV) lanes can be deployed in areas where existing car/van pool and bus traffic would benefit from an exclusive lane. At interchanges where on/off ramps are congested, queue by-pass lanes could be implemented for HOV to save time by not waiting in the queue. Congested areas of freeways could be equipped with an HOV lane where time savings would be at least one minute per mile.

By instrumenting the freeways and the parallel arterials, predictive algorithms could be utilized to balance traffic flow between the freeways and the parallel arterials. Variable message signs (VMS) and highway advisory radio (HAR) could be used to send messages to the motoring public regarding which route is less congested or which route is more congested. The algorithm predicts when the less congested route will become more congested and relays the message to the VMS and HAR to stop shifting traffic. This balancing may change from time of day or time of year and may be based upon historic data as well as sensor information that counts the number of vehicles shifting.

### D. Roadway/Weather Monitoring

Roadway/Runway Weather Information Systems (RWIS) are finding increasing use in locations where localized temperature or precipitation conditions can disrupt traffic, or require roadway maintenance activities. The most common use is for monitoring visibility and road surface freezing conditions for traveler information, or for dispatch and management of snow and ice removal crews. The responsibility of the National Weather Service is for general and severe weather forecasting. This role often does not provide detailed, up-to-the minute data needed to optimize the management of roadways due to local conditions. Additional value added services which provide site specific forecasts based on RWIS data have proven effective in snow and ice control.

Currently available technology can monitor pavement surface conditions, especially temperature which can be as much as 7°C warmer than the air temperature at the start of a storm, and can lag several hours behind the temperature of the air as it cools. An inverse situation is surface radiation cooling on a clear night, resulting in a roadway surface that is below freezing and icing from water vapor in the air.

The first situation, when managed based upon roadway surface conditions can result in several hours of delay before ice control chemicals are required. This delay reduces labor costs and materials costs for effective ice management. By extrapolating the data, the freeze point can be predicted so that chemicals can be applied on a pro-active basis, rather than reacting to conditions. Manpower and materials can be saved when knowledge of roadway conditions is available in advance. An ice/pavement bond can be prevented with far less chemical application than would be required to remove ice that has formed on the pavement surface.

The second situation, where unexpected icing conditions develop can be detected and alarmed by a weather monitoring system. This alarming can be used to dispatch sanding and salting crews in a timely manner to reduce the hazard and the resulting accidents.

Roadway weather information is also useful to monitor subsurface conditions that may be cause to restrict the travel of heavy vehicles. Major damage to roadway surfaces can occur during thaw cycles when the sub-surface can take on a plastic consistency. Application of pavement treatments can also be performed during seasons when conditions are variable, provided that roadway surface temperatures can be expected to remain within acceptable range.

Weather monitoring systems can provide a variety of data inputs including roadway surface temperature, surface condition (dry, wet, ice, dew, frost), chemical concentration on roadway surface, sub-surface temperature, air temperature, relative humidity and dew point, wind speed and direction, precipitation rate and type, and visibility. This data, when monitored locally and tracked over time, provides additional information for effective management and decision making. Specialized analysis of the data, when combined with wider area weather information, can be provided by a service organization staffed by professional meteorologists. This additional analysis provides forecasts and interpretations of conditions that can enhance the management of the area roadways. Nearby states that have installed roadway weather monitoring systems include: Pennsylvania, Ohio, Virginia, Indiana, Illinois, Tennessee, and the District of Columbia. Many agencies on the East Coast and northern mid-west have reported beneficial operation from use of weather monitoring systems.

**Communications**

Communications between the remote sensor station, called a remote processing unit (RPU), and central processor unit (CPU), should be reasonably frequent during critical periods. The RPU should be programmed to call the CPU upon detection of various types of threshold parameters, as well as periodic updates to confirm proper RPU operation. As many as fifteen to twenty calls per day should be anticipated when weather is critical. The method of communication to be used should be selected on the basis of availability, reliability, and cost. The obvious choices include: leased line, standard telephone, cellular telephone, packet radio, and owned communications infrastructure that includes existing radio and cable facilities. Data transfer requirements are only a few hundred bytes per inquiry, so standard communication rates and low cost modems can be utilized.

**Remote Systems**

An RWIS field site consists of surface sensors, atmospheric sensors and a field microprocessor (RPU). Each field site costs about $25,000 to $30,000. A central computer, together with communication ports and modems, collects the data from each field site on a regular basis. A software package in the central computer stores and analyzes the data, and presents it in graphical and tabular form. The central hardware/software package costs about $30,000.

**Preliminary Communications Recommendations**

A good candidate for communications of RWIS data is cellular packet radio. Packet radio was developed for the transmission of data. This communication technology is not likely to be in heavy use during severe weather emergencies. Cellular telephone systems, on the other hand, could be overloaded when they are needed the most. At present, each application to be used on packet radio requires certification by the carrier. This could involve some costly software modifications to adapt to the packet protocol. The use of packet radio should provide a rapidly implemented reliable and cost effective means of data communication to areas where wire lines may be difficult to install.

# CHAPTER V

# REGIONAL COMMUNICATIONS AND ARCHITECTURE

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# V. REGIONAL COMMUNICATIONS AND ARCHITECTURE

## A. Introduction

Various communication options are available to carry voice, digital serial data and video information within the project corridor. When transmission of a large number of different video signals is necessary, as would result from a network of traffic monitoring and surveillance cameras, the video communication becomes a major part of the communication design. A number of low speed communication channels for voice and data can be combined by use of multiplexers onto the same transmission facilities used for wide bandwidth video channels.

Two primary alternatives are available for system communications: commercial circuits, or agency owned circuits. Typical systems use a mix of these alternatives, driven by costs and requirements. Excellent, extensive treatments of this topic are provided in literature, in particular the "Communications Handbook for Traffic Control Systems" published by the FHWA in 1993.

Communications technology is rapidly changing, providing faster and higher capacity circuits at lower costs. New wireless options are emerging, spurred by growth in portable computers and personal communications. To take advantage of these changes, the system communications architecture must be flexible and designed around common and commercially supported standards.

The following summary reviews those items most applicable for the Rochester project. Since the communications system is usually the most expensive component of a traffic monitoring/incident management system, it is crucial that a full range of options be considered and evaluated.

## B. System Requirements

Various types of communication channels will be required by an Advanced Transportation Management System (ATMS) for the transmission of video, data and voice information. To obtain an overview of the types of communication required, consider the typical actions of an ATMS:

- Automated incident detection is provided by the interpretation of data collected from traffic sensors distributed through the roadway network. This data is usually transmitted on voice grade channels.

- Verification of computer detected incidents and a check of alternate routes with video cameras, requires the transmission of video signals from cameras installed along the roadways.

- Camera positioning signals that direct pan, tilt and zoom commands to the camera, are usually transmitted on a voice grade channel.

Control signals for variable message signs, roadway weather information systems, highway advisory radio and ramp meter controllers, are also usually transmitted on voice grade channels.

A series of subsystems is utilized to provide a range of management and control options to the Traffic Operations Center (TOC), for operation of the highways under incident conditions. The various types of communication necessary are discussed in further detail in subsequent sections.

The roadways to be covered by ITS equipment and the phasing of the development of the ATMS can be found in Chapter 9, "Strategic Implementation/Deployment Plan". The physical layout of the roadways to be covered is discussed and a time frame for implementation is proposed. The chapter provides the list of equipment and the associated phase when it will be deployed.

It should be noted that there are benefits that can be derived from communications infrastructure for both the interstates and the arterial roadways within the Greater Rochester Area. When a private communications firm is interested in cable routing along a section of roadway in the area, a partnership should be pursued on the presumption that in the future there will be a need for some sort of communications infrastructure. The NYSDOT, Monroe County DOT or the individual cities whose rights of way are involved should see to it that, at a minimum, an empty conduit is installed for future use. This should occur whenever anyone, a private communications firm or a government agency is installing anything longitudinally in the roadway, especially if there is no cost to the governing agency. Monroe County DOT has established a procedure that whenever a roadway within their jurisdiction (or within the UTCS traffic signal system) is under construction, there is an opportunity to install new conduit.

### 1. ATMS Communication Requirements

Various types of information must be communicated in any traffic management system. The communications will consist of voice, binary serial data and video signals. Various types of pre-processing and data conversion may be performed on the communication signals that must be transmitted. Signal pre-processing reduces the amount of communication bandwidth, duration and rate of transmission required. Data conversion can provide for the transmission of signals that would ordinarily not be compatible with available media.

Communication of various types of control signals from the TOC to field devices will also be necessary. Some examples of the types of messages required include: detector polling and the control signals required to transmit messages to VMS, timing changes to ramp meters, and pan, tilt and zoom commands to CCTV cameras. Most if not all of this communication has been standardized to operate on voice grade channels, presently for the most part at or below 9600 bps. Direct digital connection for serial data is usually provided on RS-232, RS-422, or RS-485 channels. Communication should be structured in a byte oriented format to permit direct communication with IBM compatible personal computers (PCs). A protocol that details the type and format of communication expected for each type of device should be developed to provide standardization of data communication.

*a. National Architecture*

The ITS Architecture Development Program, sponsored by The US Department of Transportation (USDOT) and the Intelligent Transportation Society of America (formerly IVHS America, now ITS America) is a national initiative expected to create a $200 billion industry related to the application of Intelligent Transportation Systems over the next 20 years.

In November of 1994, four selected teams let by Hughes, Loral, Rockwell and Westinghouse submitted initial architectures for this program. The Loral and Rockwell teams were selected to continue this development into a single architecture with national consensus. They are expected to integrate the best elements of other approaches as applicable. It is expected that a preliminary national architecture, requirements for interface standards and associated implementation strategies will be in place by early 1996.

ITS America has suggested that the communication and protocol standards developed by the Electronic Industries Association (EIA) and their Telecommunications Industry Association (TIA), as well as standards of other recognized agencies, be utilized to provide standardization of communications, messages, protocols, and formats. These protocols include video and data transmission requirements and interface standards. When data communication is standardized to allow communication to be accepted by a standard interface, as may be found on a typical PC, the costs associated with future expansion and maintenance should be reduced and useful life of the product may be extended.

The consolidation of nearly all ATMS communication functions to a fiber optic system is cost effective but seems to put all the (traffic management) eggs in one basket. Even though this system can be designed with redundancy, there are circumstances when a failure that can stop most signals from getting through could become a possibility. When this link is interrupted, a standby plan should be in place to recover beneficial use of some critical assets, until the primary communication system can be restored to full operation.

*b. Communication Standards and Protocols*

A communication protocol defines a common set of rules and procedures to prevent incompatibilities in the messages that are sent between remote sub-systems and the ATMS central computer. A standardization of interfaces should lead to a reduction of costs by elimination of custom interfaces, provision for portable software and common maintenance/support.

Some standardization may, however, have an opposite effect. A system supplier may have developed the majority of their software with utilization of a proprietary protocol. Requirements for a specific protocol could lead to higher initial costs to provide for integration and system development of this protocol. However, if reasonable choices are made and appropriate standards utilized, the standardization that results will provide benefits in the long term.

The various types of message protocols considered here are those that will be utilized for:

- Voice Communication Standards
- Detector Communication
- VMS Control
- Ramp Meter Control - future possibility
- ETTM Protocols for Traffic Management
- HAR Communication
- RWIS Protocols
- Video Communication Standards
- Closed Circuit Television Standards
- Camera Control Protocols
- Traveler Interface Protocols
- MCDOTAJTCS Interconnection with ATMS
- Future Information Sharing Possibilities

Establishment of standardized protocols for the project will limit the use of proprietary protocols that may restrict future multi-vendor compatibility and allow for ease of future growth with development of an open standard.

*c. Voice Grade Communication*

In general, most collection of data and distribution of commands to remote devices will be performed over voice grade channels. Most present traffic devices utilize voice grade channels for communication. Standard voice channels can be utilized to communicate with HAR and provide the person to person communication that will be required. Maintenance telephones and discussion capability with other agencies and system operators are examples of possible voice communication needs in an ATMS. In digital communication systems, the transmission of voice is performed by first digitizing the analog voice information and then packing the digital data stream with other signals to be transmitted in a multiplexed fashion on a single channel. In this way, a single high speed channel can transmit many separate lower speed channels of voice and other data.

*d. Voice Communication Standards*

Transmission protocols and standards are utilized to allow telephone calls to be placed between the various companies that provide service across the country and around the world. SONET, a Synchronous Optical Network, is based on a standard that provides for multiplexed channels on an optical carrier. The lowest level of SONET multiplexed signals is OC-1 at 51.84 Mbps. The most commonly available SONET multiplexers provide standard rates of OC-3, 12, and 48. The OC-N data rate is simply N x 51.84 Mbps. Rates above OC-48 are in development.

The older standards for voice multiplexed circuits called asynchronous multiplexing, are still in common use and include: DS1 at 1.544 Mbps and DS3 at 44.736 Mbps. Equipment is available to translate between systems and combinations of DS1s or a DS3 can be mapped into an OC-1. With asynchronous multiplexing, it is necessary to disassemble the entire packet to retrieve a DS1 signal. Under synchronous multiplexing, DSl signals can be directly extracted from the data stream. This makes drop and insert operations simpler to perform with Synchronous Digital Hierarchy (SDH).

### 2. Detector Communication Protocol

Information about traffic conditions is collected from vehicle detectors. This information should be pre-processed and aggregated to reduce continuous transmission requirements for data collection. When pre-processing is performed, the details about the presence of vehicles over specific points are collected and processed remotely. This provides several benefits:

- The central processing load is reduced.
- The need to instantaneously transmit the collected data is eliminated.
- The channel bandwidth can be lowered, reducing the cost of transmission equipment.

A number of types of traffic sensors are available for use in an ATMS. Data from these sensors should be provided to the ATMS in a standardized format or communications protocol. With a standardized format, various types of sensors can be easily mixed into a single system. The sensors that are used to detect traffic range from loop detectors to sophisticated video image processors. All can be either connected to a pre-processing controller along the roadside or can be programmed to provide a standardized output format for communication to the TOC. A serial data structure can be used that will contain the required parameters to simplify the task of automated incident detection. It is expected that parameters such as: volume (vehicle count over an interval), occupancy (a measure of the congestion level), and speed will be required. The choice of an incident detection algorithm should lead to the specific parameters necessary. To reduce the need for frequent communication, pre-processing to provide calculated results associated with the preceding data collection time interval, should be performed. This pre-processing will also serve to reduce the amount of central processing necessary to handle the incident detection task.

Pre-processing of detectors can be performed by a low horsepower intelligent controller such as a Model 1701179. Controllers of this family are well suited for communication. Standard, plug-m modules have been developed by a number of manufacturers for various types of detectors and communication media. Higher powered intelligent controllers such as the recently developed Model 2070 controller with VME bus capability, may be required if a great deal of specialized processing or heavy communication load is required.

Communication with each detector station on a periodic basis is important to verify proper operation. The periodicity of communication should be fast enough to provide timely information for incident detection, yet slow enough not to consume unnecessary communication time. Efficient incident detection would suggest communication about every 15 seconds or less. A polled interrogation of each detector station in sequence is commonly used to collect data.

Development of a significant data collection sample for pre-processing suggests an interval of 5 seconds or longer. The specific parameters to be transmitted may include volume, occupancy, speed, headway and results of various calculations that may be performed on the collected data including comparisons with previously collected information. Comparisons with data collected at other stations is probably best done at a central processor rather than distributed among the data collection and accumulation sites.

Transmission of four parameters per detectorized lane should be considered a minimum. Actual implementation could include the transmission of eight or ten parameters. This relatively high count allows for data collection of standard parameters for traffic analysis and possible future research towards improvement or revision of the detection algorithms. The final byte should be reserved for CRC error checking. Unused space, allocated for additional parameters in the detector protocol, introduces inefficiency but at this point does not interfere with other required operations. Some existing protocols communicate additional parameters only when requested in the polling message. The use of variable length messages introduces a level of complexity that is probably not necessary.

An initial protocol for detectors can be developed based on use of a combination of the single station McMaster and the multi-station Modified California Algorithm. This detector communication protocol would require transmission of volume, occupancy and occupancy difference comparisons with a previous interval. Further calculations and comparisons with adjacent locations could be performed at the central computer for locations with significant temporal occupancy differences reported in the pre-processing calculations.

Considered as an example, a full duplex, asynchronous data transmission protocol could consist of one byte allocated for each parameter. Each byte (consisting of eight bits) can hold a positive integer from 0 to 255, or a signed integer from -127 to +127. Two additional bits of overhead are required to provide start and stop bits in a standardized asynchronous data transmission format. This structure requires a minimum of 10 bits for transmission of each byte. With 10 bytes utilized by each lane, and transmission at 1200 bps (probably the most common rate used for twisted pair traffic data), would allow 12 lanes to be transmitted per second on each channel. A standard detector station could be defined with a maximum capability of twelve lanes. Under these conditions, with a detector station every half mile, five miles of roadway detectors could be accommodated in 10 seconds of data. This type of protocol could operate with polled detector stations responding to interrogation nearly every 10 seconds. The actual rate will include delays for re-synchronization of the receiver to each transmitter and other small transmission start-up delays, that will add a few small fractions of a second to each transmission. Modems that operate at higher speeds often take a significantly longer time to re-adjust when the carrier is toggled, as it would be in a polled communication system.

Fiber optic technology has provided high speed modems that can respond without the need to restart transmission of carrier signals at each poll. A disadvantage of this type of linear (daisy chain) connection is that the failure of a single element in a chain, can block all communication in the segment served by that chain. Fiber however has provided significant advantages including elimination of interference (RFI and EMI) and reduction of the potential of damage from lightning.

### 3. VMS Protocol

Communication with variable and changeable message signs should be performed periodically to verify proper operation. The periodicity of communication is not as demanding as detector polling, but a similar polled communication protocol can be applied to this operation as well. Standard data rates on twisted pairs are generally between 1200 and **9600** bps. Current asynchronous standards provide the most rapid switching and synchronization of twisted pair transmitted data at 1200 bps with use of Bell 202 type modems. In situations when VMS controllers are directly connected and time constraints are not tight, Bell 212 type modems offer lower cost and better availability of replacement devices. Fiber optic connection of VMS is frequently performed at 14,400 bps.

Some variable message signs are configured with a library of pre-canned messages for quick display as conditions dictate. This type of VMS can be commanded as a changeable sign (CMS). Increased flexibility is provided when the text for a message to be displayed can be down loaded to the sign from the Traffic Operations Center.

The VMS communication protocol should also allow for the possibility of CMS type messages. Communication with each sign controller can be on an as-required basis, with some periodic communication to verify operability. Signs that are connected to the owned backbone communication system might be polled every few minutes to rapidly detect a malfunction. Those signs that are connected by communication services where charges are imposed or each access might communicate much less often for status checks. A common protocol would allow permanent connection of signs that have been deployed on a temporary basis to areas not on the communication backbone without need for major hardware modifications.

### 4. Ramp Meter Protocols

Ramp metering on most projects has been controlled by the Model 170 series of controllers. There are two software developers that have experience working with this type of control, Bitran and Wapiti. These developers have utilized both open and proprietary protocols for communication with Model 170 controllers. It has been found that changes and improvements are incorporated in communication protocols as they are used in operations. It is not recommended that a protocol be developed or adopted now for future ramp metering. When the need arises for this communication, there should be more standardization in effect. Sufficient spare capability, including computer time and hardware ports, must be designed into the control system for future needs.

### 5. ETTM Protocols for Traffic Management

ITS America is involved in establishing requirements for Electronic Toll and Traffic Monitoring (ETTM) communication between vehicle and roadside using advanced technologies. This platform interfaces though OSI levels 1,2, and 7 to provide message exchange.

An Inter Agency Group (IAG) that consists of the toll authorities in New York and several neighboring states, has been developed to standardize electronic toll collection in the area. Cooperation between agencies is leading to unified procurement of a toll tag system dubbed EZ-Pass. When the vehicle population includes a significant penetration of EZ-Pass tags, use of vehicles with electronic tags as active probes to sample travel time could be effective. At the present time and for the near future, it is not expected that a sufficient number of vehicles in the Rochester area will be equipped with electronic tags to provide an adequate sample for traffic monitoring.

### 6. Highway Advisory Radio Control Protocols

Most Highway Advisory Radio (HAR) systems use tone controls and voice signals as provided from a touch-tone telephone for communication between a HAR message recorder and TOC. Other systems utilize a data connection and can accept digitized signals for control and rapidly down-load voice messages. The voice channel for HAR is usually a telephone circuit and may be served by direct connection, telephone line or cellular telephone. Voice prompts are offered by some manufacturers to provide ease of operation. Functions include message monitoring, initiating and terminating record mode as well as transmittal and auxiliary equipment operation. In order to accommodate HAR operation, one voice grade channel per five mile section of roadway should be allocated in the interconnecting cable for communication. If a digital HAR control is to be utilized, the communication to each site should operate effectively with rates at or above 9600 bps.

Radio Frequency (RF) synchronized HAR has not yet been developed to permit a wide coverage area on one frequency using multiple transmitter sites. A system has been proposed for I-80 MAGIC in New Jersey and some results should be available by early 1996. Systems that utilize “leaky cable” antennas placed along the roadway, provide a form of RF synchronization along the length of the antenna. The signal strength of this type of system diminishes rapidly a short distance away from the antenna route.

When more than one transmitter is operated at the same assigned frequency, interference between signals, called heterodyning, is produced. This interference results from slight differences in transmitter frequencies. Although most transmitters are crystal controlled, and closely regulated, slight differences in frequency are more common than not. Two individual transmitters produce signals that boost each other when the signals are in phase and cancel each other when they are out of phase with each other. This relationship produces undesirable beats or whistles in the signal. In some areas of the country, systems are presently in operation with multiple transmitters. These sites are operating reasonably well with only audio synchronization. When a vehicle is in a fringe reception area between two transmitters some interference may be noticed.

The transmission frequencies available for HAR and Travelers Information Stations (TIS) were limited to only 530 or 1610 KHz. In 1992 this was changed to permit use of any sufficiently open frequency in the AM band. Commercial radio stations, however, have priority in frequency selection. If a commercial station wishes to operate at the frequency licensed to a HAR/TIS, the commercial station will usually be granted the frequency.

At the present time, the New York State Thruway operates HAR./TIS stations in the area and frequency coordination/selection will need to take this into consideration. Some HAR manufacturers will provide services for frequency coordination and licensing without additional charge, when their equipment has been selected.

### 7. Roadway Weather Information Systems (RWIS)

Information about roadway surface conditions can provide a cost savings in material and labor required to manage efforts to keep traffic moving and highways safe during periods of ice and snow. The conditions detected by weather sensors in a local area are collected by a remote processing unit (RPU) Weather data is then communicated to a central processing unit (CPU) for consolidation and interpretation. The communication between RPU and CPU can be only a few hundred bytes of information that may need to be transmitted several times a day. During severe weather, the need for current conditions may reach a few times per hour. Due to the small data load, a low speed communication channel is adequate for this connection. In locations where access may be easily obtained to high speed ATMS communication lines, it is reasonable to include RWIS communication with the other devices along the roadside such as detector stations, CCTV, and VMS. Communication from the main RWIS CPU to a remote CPU (perhaps located at maintenance headquarters, to allow wider access to weather information), can be accommodated on a Local Area Network (LAN) connection. If the remote CPU is sufficiently remote, Wide Area Network (WAN) techniques may be required to provide this interconnection. These techniques may include bridged transmission between LANs on a telephone connection, or extension of the LAN by fiber optic connection to a remote CPU.

## 8. Video Communication Standards

Broadcast video signals in the US conform to the standard utilized for broadcast television that was largely developed in the 1950s by the National Television Standards Committee (NTSC) These video signals occupy a 4 MHz base-band and utilize 6 MHz of bandwidth for transmission. There are several other standards presently in use in this country. These standards provide increased resolution and result in higher quality video. These standards are mostly adaptations of NTSC video that include: Component Video (RGB) and Luminance/Chrominance or Super-VHS (Y/C or S-VHS). These formats allow higher bandwidth transmission to achieve a near “studio quality” picture. There are other standards used in foreign countries, but these do not offer significant advantages compared to the confusion that would result if utilized here. A number of standards have been proposed for High Definition Television (HDTV) as the future broadcast television. Evaluation of these standards is underway by a number of organizations, including AT&T, GI, MIT, Philips, Sarnoff, Thompson, and Zenith, collectively termed the Grand Alliance. Since 1993, the Grand Alliance has resolved many problems and worked with the FCC to come up with a unified HDTV standard that contains the best features of the previously competing proposals. The final format will probably be a compressed digital protocol at about 200 Mbps. Both final FCC approval and development of equipment are still in the future. It is anticipated that a completed official standard may result before the end of 1995. However, even after HDTV products become available, there is a 15 year transition period anticipated to phase in the new technology. During this interval, potential plans can be evaluated to upgrade systems that will be in operation. For present purposes, NTSC video provides sufficient resolution of detail at reasonable cost, and should be utilized in this design.

NTSC video is normally transmitted on an analog channel. If a high bandwidth digital channel is chosen for transmission, it will be necessary to convert the video to a digital format. Direct analog to digital conversion preserving the degree of resolution that is usual for television broadcast quality images results in a required digital data rate of roughly 100 Mbps. Digital transmission of this type of signal in communication networks is not commonly performed except by television broadcasters. Digital transmission of nearly full bandwidth video is often performed at 44.736 Mbps, the telephone standard DS3 rate. This rate is equivalent to 672 telephone voice channels. In order to pack the video signal into roughly half of the digital space that it would normally occupy, the signal must be encoded. Devices called video codecs are available at a cost of about $5,000 to encode or decode these signals.

Signal packing to reduce the data rate even further is available, but more expensive. Video codecs able to operate with signals employed on T-l lines (called DS1), are necessary to perform this degree of compression, at a cost of about $20,000. The DS1 rate is equivalent to 24 telephone voice channels. Prices in this technology are beginning to fall rapidly. It can be expected that DS1 video codecs will soon be available at much lower prices.

Some video compression standards are beginning to be recognized. The most common standard, H.261 often used in video conferencing, allows for multi-vendor compatibility. This is important because video data encoded in a standardized format can be shared between agencies, as faxes are transmitted today. Additionally, a system that conforms to a recognized standard is less likely to rapidly become obsolete. Most proprietary compression schemes usually provide features not available on a standardized version, offered by competing manufacturers. As progress is made in this industry, it can be expected that some codecs will adopt a common standard and also offer proprietary features that can be supported only with compatible equipment at both origin and destination. This is the development path that fax machines have followed.

**9. Closed Circuit Television Standards**

A standard NTSC camera provides full motion video with broadcast quality on a 6 MHz channel. Cameras are available that provide color or monochrome video. Color is generally more visually attractive, however, equivalent cost monochrome cameras have higher resolution and better light sensitivity. Various types of video compression have been developed to reduce the bandwidth of video signals. Generally, when the bandwidth is lowered considerably, the signal can be transported more economically. The reduction of bandwidth however, will have a detrimental effect on image resolution (quality) and/or refresh rate (appearance of full motion). These factors may reduce the utility of CCTV as a traffic condition and incident verification subsystem. If resolution is not adequate, a clear picture of an incident cannot be viewed. If the refresh rate does not provide full motion, camera positioning becomes an effort of trial and error. Presets, if available, can be used to position the camera to pre-programmed positions. But the view required cannot always be known beforehand. Without full motion, it will also be difficult to determine the rate that vehicles are moving and whether free traffic flow is being observed. It is recommended that a video system which includes both full motion and full resolution capability be installed.

**10. Camera Control Protocols**

Proprietary systems unique to various system manufacturers are the norm for camera positioning and monitor selection. Each manufacturer has a unique encoding scheme that will not operate with another vendor's equipment. There is however, a small degree of commonality that can be found in many systems. Usually, communication with the remote camera controller is either provided or can be accommodated on a serial voice grade data channel. In this way the communication design can be developed without selection of a specific manufacturer's product.

The provision of one multi-dropped voice grade channel for each control section of roadway should provide adequate latitude for most manufacturers to operate their systems. The optional use of bi-directional fiber optics or additional linear distribution should also be considered for future communication growth beyond voice grade channels for camera control.

## 11. Traveler Interface Protocols

Various options are available for the dissemination of traveler information. These include Highway Advisory Radio previously discussed; Highway Advisory Telephone (HAT), in both voice and data formats; and subcarrier data transmission. Only a voice format is presently in use by agencies that provide HAR and HAT service in this area. A digital data format could be developed for use with computers, where highly compressed traffic information covering a wide area would be repeated on a radio subcarrier or telephone connection similar to that presently used for voice HAR, or telephone weather and time information.

Some future ITS scenarios suggest use of broadcast radio or television subcarriers, to disseminate digital traveler information. The use of subcarriers is not new. Various systems have been in use for nearly 40 years for the transmission of services such as MUZAK Subcarriers are virtually unregulated by the FCC and can be applied in varying bandwidths to most broadcast transmitters. All that is required to transmit a subcarrier message is a communication link to the broadcast station with which an agreement has been made for transmission of the signal. The broadcast station may also require some minor hardware upgrades to enable subcarrier transmission.

It is expected that automatic scanning features will be incorporated into radio receivers designed to receive this data subcarrier. Equipped with automatic scan, a moving vehicle could seek out a station transmitting messages relevant to the surrounding local area or the route that is being traveled.

One proposed scheme includes subcarrier transmission of data that would be repeated roughly every minute. This would allow a computer that had just connected to the message to get a full update of conditions in a reasonable amount of time. The message would consist of a complete database containing encoded current traveler information. The data would include conditions on each instrumented roadway link, variable message sign, and scheduled construction in the area. This repeating message could be decoded by specialized software on a PC, or specialized hardware that would be developed for use in vehicles. This type of transmission could be used to develop a map of traffic conditions specialized for each user, or to make recommendations of the best route for individual trips.

Highway Advisory Telephone is presently being used by a number of agencies including the New York State Thruway, New Jersey Turnpike, and Garden State Parkway. Some agencies operate with a toll free 800 number available from any location within the state, while other agencies offer only standard access with calls charged to the calling party. Traffic information for the associated roadway is recorded in a message that is repeated to callers, similar to the messages disseminated on HAR. It is important to maintain accurate current conditions and to provide timely updates when conditions change, on all traveler information services. In Chicago, a HAT system (708 705-4620) is linked to digitized voice message segments that are automatically updated when congestion levels change on the freeways.

### 12. Interagency Communication

It is expected that incident video will be shared between the New York State ATMS and the Monroe County UTCS systems, especially if the facilities of the County are utilized for some of the video communication. Accessibility of traffic data or diversion information is also expected between agencies, and on-line communications protocols between the two systems may also need to be developed. A full system linkage utilizing LAN or Bridged WAN on the fiber optic cable could be established to interconnect the two facilities. As another consideration, simply a system terminal for the remote system at each facility would permit control during periods when one system is unmanned.

### 13. Future Information Sharing Possibilities

There is a great deal of cooperative spirit and information sharing active in the Rochester area. It may not be necessary to form a separate information sharing agency such as INFORM or TRANSCOM to provide specific information sharing capabilities in this area. Standards and protocols for information that is shared should agree to the extent feasible with any standards proposed nationally or developed for information sharing in nearby regions.

Additions-to the County architecture or any sharing of communication facilities should not impede any existing emergency communication systems, or the timely access or exchange of information. The ATMS presents opportunities to enhance the County's Public Alerting System. Various ATMS components including Highway Advisory Radio and Variable Message Signs provide opportunities for further cooperation and mutual benefit.

## C. Existing Communication Infrastructure

Several agencies in the region operate systems that have associated communication infrastructure. This section describes how these existing facilities might be utilized by the ATMS for the transmission of required signals.

### 1. Monroe County UTCS

The existing Urban Traffic Control System (UTCS) has been in operation for about thirteen years. During this time, the technological advancements in computers and communications has provided equipment far superior to what was available in the past. Traffic control systems running software based on UTCS designs are presently available on standard, Intel based, personal computers. The processor for such a system can be expected to cost less than the annual hardware maintenance budget (now $23,000 per year) for the Concurrent 3220 system. Communication between the computer and Traffic signals is performing well on owned coaxial cable. However, the maintenance required for the coaxial cable based communication system is considerable and replacement cost of remote communication units (RCUs) is high ($5,000 to $6,000 per unit).

The major component of existing communication infrastructure is the coaxial cable plant that is used for control of traffic signals. The system has been well maintained and operated by Monroe County, but since costs continue to rise, the County has expressed a desire to convert the system from coaxial cable to fiber optics.

Based on the probable conversion of the UTCS communication system, it is suggested that the coaxial cable facility not be utilized as a major component of the communication system for the ATMS. This will allow the county to make the best choice for the needs of the Traffic Control System without the constraints that would need to be considered if their existing communication system was highly intertwined with the proposed ATMS.

### 2. UTCS Coaxial Cable Operation

The cable used for Rochester area traffic control communication (shown in Figure V-l) has bandwidth available to carry standard video signals, each of which occupy a 6 MHz channel. The system was designed with most of the bandwidth in the inbound direction. There is roughly 250 MHz available with only about 5 MHz in use by UTCS. In the outbound direction, of the 25 MHz available, traffic control and voice communication for maintenance are assigned frequencies that leave bandwidth for only about two video channels. It is not likely that the UTCS coaxial cable system can be used to transport the video required for the ATMS from source to destination. A discussion of how the system might be used to collect video signals for the ATMS follows.

The way in which most two way coaxial cable systems operate is described here. Signals that originate at the cable head-end are transmitted down the cable in the band that has been established for the downstream direction. The Rochester UTCS system utilizes the 5-30 MHz band for these outbound signals. Inbound signals are collected at the head-end in the 50-300 MHz band. This configuration allows many remote high bandwidth devices to transmit to the head-end. If Monroe County were to add video surveillance, the cable system would be an inexpensive means of communication for video signals from the cameras. There is sufficient bandwidth for 30 to 40 surveillance cameras. Cable systems that distribute entertainment to their subscribers have an opposite configuration, with most of the available bandwidth in the downstream direction.

In order for a signal to be transmitted from a connection on one remote branch to a connection on another branch it must first go upstream to the head-end. All inbound signals that are to be re-transmitted from the head-end, in the outbound direction, must be shifted in frequency. This is because upstream and downstream signals must be kept in separate frequency bands. The field maintenance telephones included in the UTCS communication system operate in this way. The field telephones receive at 13 MHz and transmit at 59.3 MHz. An up/down converter installed at the head-end performs a frequency translation to shift inbound field telephone signals at 59.3 MHz, to be transmitted from the head-end at **13 MHz.** Communication with a second field maintenance telephone set is now possible. Some additional small frequency shifts are added to prevent audio frequency heterodyning squeal produced when two transmitters operate with nearly identical frequencies.

Rather than retransmit the video signals collected at the head-end, a separate fiber link could be constructed to carry video signals from the UTCS to the ATMS. Video signals from cameras located in proximity to the cable route could be collected using the inbound direction of the UTCS cable. These signals would then be re-directed onto the separate link from the UTCS system head-end to the ATMS. Such a configuration could provide a means of collection of video signals in areas covered by the UTCS. This discussion has presumed that the coaxial cable system would be retained. If it is replaced with fiber, cameras could be connected to individual fibers, or multiplexed for transport to the ATMS.

### 3. Monroe County Pure Waters Fiber Optic Cable

Pure Waters has installed a fiber optic cable (shown in Figure V-2) to provide control and supervision of waste water systems. This cable runs about six miles from the Iola Campus County offices on East Henrietta through the center of Rochester to the Pure Waters facility at Durand Eastman Park near Lake Ontario. There are several fibers that are presently not committed for use and could be shared with another agency. There may not be much need to transport signals on this route, however additions to the cable system interconnecting some of the Monroe County Agency buildings may fill some needs of ATMS communication.

### 4. Monroe County Microwave Communication System

There is a hubbed microwave communication facility operating on five towers in Monroe County (shown in Figure V-3). The towers are arranged in a generally east west pattern. The microwave system is presently a 96 channel analog system, but soon will be upgraded to a 632 channel digital facility. The system will have some surplus audio channel capacity, however the transmission of video signals is not an available option. The available capacity could allow room for a few DS1 channels. This may provide some interim video capability, however codecs that operate at DS 1 rates are relatively expensive (about $20,000 each). If consideration is given to use of these interim facilities, there should also be consideration given to the long term use for the codecs that are necessary to access the facility.

## D. ATMS ARCHITECTURE

The communication system is usually the most critical and expensive portion of a traffic management system. To provide proper operation, an efficient and cost effective architecture must be utilized. The various architecture alternatives are usually characterized in one of three major classifications:

- Centralized or direct connection to the control center provides communication without intermediate processing.
- Distributed architectures utilize a field concentrators to improve communication efficiency by introducing various data rates in the communication stream.
- Hybrid architectures utilize features of both centralized and distributed architectures.

A backbone communication system operates with a distributed architecture using a high speed data link to transmit data for a number of distributed low speed devices. A backbone architecture is able to provide efficient communication to all field devices in an economical fashion. When the need arises for additional high bandwidth links in the future, connections can be made to spare single mode fibers that will be contained in the backbone cable. The Rochester ATMS communication architecture is illustrated in Figure V-4. Direct point-to-point (star) and polled linear connections (bus) provide efficient, low cost, easily maintained connections to field devices.

The existing relationships with other agencies should be retained on a personal level with dial-up telephone connections. If it is found that the connection procedure becomes tedious, automatic dial features should be provided. Where frequency of contact becomes excessive for dial-up connection, direct connections can be provided either on spare capacity in the backbone (if near an agency office), on an existing fiber system (as is presently in use by Pure Waters), or on leased circuits.

### 1. Conduit Installation Standards

In this era of Intelligent Transportation Systems and heavy communications needs to support these systems, many transportation agencies have begun to install empty conduit in anticipation of this need. Figure V-5 displays some typical conduit installations standard drawings. For example, in New Jersey the DOT has decided to stack the conduit (2-4" rigid non-metallic conduit) on top of each other in a 6 inch wide trench. The backfill in the trench was settling unevenly so the decision was made to completely fill the trench with concrete and pave over the trench. In Washington State, the DOT has two types of installations. One type has two conduits buried side by side in a 1 foot - 7 inch wide trench. The trench is backfilled with a warning tape. The other type has four conduit in the same size trench, side by side and stacked.

Several agencies include innerduct in their conduit. This provides extra non-obtrusive space for additional cable to be pulled through the conduit. There are different types of conduit with innerducts. Fiberglass conduit has a number of chambers (often four) molded right into the conduit. With more standard rigid metallic and non-metallic conduit, innerduct must be pulled through the conduit to provide separate raceways for cable. Some manufacturers now produce pre-assembled multiduct in PVC and other materials. Other manufacturers offer duct with special ribbing to reduce friction on long pulls often associated with fiber optic cables. These ducts are available on large spools to reduce frequent junctions that can introduce moisture and subsequent freezing problems into a conduit system.

The largest single cost item of installing a buried agency owned cabled communications system is excavation. The cost could range from $25 to $35 per linear foot to excavate soil or pavement, while the cost of the conduit ranges from $1 to $2 per linear foot with or without an inner duct system. During roadway construction; milling and resurfacing or widening with total depth reconstruction, the contractor may be willing to negotiate a reduced rate for excavation and installation of conduit. This could result in a savings of $10 to $15 per linear foot to install a conduit system during construction. A savings of approximately 40 percent. It seems reasonable to provide for future needs by placing conduit during any major roadway construction provided that a means of record keeping can be utilized to locate this conduit when it is needed. Innerduct can be added at a later time if necessary.

**2. Fiber Optic System Architecture**

Fiber optic communications systems were initially developed in the 1960s by the telephone companies for long haul transmission of voice and data. The technology has undergone successive refinement over the past quarter-century, and is today the technology of choice for essentially all new communications systems. Early implementations of fiber optic systems replicated the existing systems that were based on twisted pair, coaxial cable and microwave channels, specifically implementing digital carrier systems at DSl (1.544 Mbps) and DS3 (43.232 Mbps) transmission rates.

Within the past 10 years, a new standard termed Synchronous Optical Network (SONET) has been developed. The SONET standard is based upon multiples of 51.84 Mbps, which is known as an Optical Carrier 1 (OC-1) channel. An OC-1 channel carries a DS3 data stream plus additional control and status information. SONET systems typically are installed with OC-3 (155.52 Mbps), or OC-12 (622.08 Mbps) capacity, with some systems implementing OC-48 (2488.32 Mbps). Faster data streams are in planning.

A key design concept of SONET is redundancy. This redundancy is achieved by the use of dual counter-rotating ring circuits. These rings provide for automatic rerouting of traffic onto the secondary ring, in the event of a failure in the primary ring. Since the secondary ring transmits data in the opposite direction from the primary ring, a cable break at one location does not result in a system failure. This re-routing capability is referred to as a self-healing ring. The switch-over from the primary to secondary ring occurs rapidly enough that most data communications can recover without data loss, however, real-time traffic such as voice or video may incur a momentary loss of communications. Restoration of full system functionality requires field repair of the broken cable. Equipment failures are also contained by the inclusion of redundant components at all key locations. This redundancy is included in the basic design of the SONET system.

While alternative configurations may be considered, SONET is the preferred choice of all new communications systems. The use of SONET by the telephone companies and long-distance carriers has resulted in a wide range of manufacturers and vendors of equipment. The resulting competition has generated a wide range of features and capabilities, and very attractive benefit-cost ratios. Other alternatives do not have the range of options and features, and typically are more expensive when compared to SONET on a functionality basis. At SONET speeds of OC-12 and above, the field of vendors is growing but not all that wide yet. The biggest players with more than two years experience at these high speeds include Fujitsu, AT&T, Northern Telecom, and Alcatel moving up rapidly.

The advantage of SONET is also its greatest drawback: the very wide bandwidth that is supported. This communications capacity results in higher costs when compared to the lower bandwidth solutions, but extending the lower end solutions to SONET capabilities ultimately requires a higher system cost. The other limitation of the higher bandwidth is the impact of a system failure, in that it impacts more field devices and communications channels. However, the self-healing capability and designed-in redundancy of SONET typically results in a more reliable overall system.

The design of a SONET system utilizes four single mode fibers on each link, preferably with two separate routings, using 1310 nm or 1550 nm for transmission. Interconnection of field devices to the SONET backbone requires the use of a “communications hub”. A hub serves to interconnect low speed (1200 bps to 9600 bps) data streams from individual 170 controllers, VMSs, etc. to the much higher data rates of the SONET backbone. This interconnection is performed by devices knows as multiplexors/demultiplexors (also called channel banks in this application). Data originating at several field devices is combined together in a “time-slice” format for transmission to the central facility. This combination makes best use of the capacity of the SONET system. In the reverse direction, the data coming from the central facility is extracted from, or demultiplexed, from the combined data stream and routed to individual field devices. An equivalent set of multiplexors/demultiplexors exists at the central facility to perform the same functions of combining and separating data.

Since voice can be represented in a digital format, the SONET system can also be used for voice communications. Digital transmission of voice is extensively used by all the telephone companies and long-distance carriers, and has been the driving force behind the development of digital carrier and SONET technologies. A SONET package includes capabilities for remote OAM&P (Operations, Administration, Maintenance, and

Provisioning) that provides a point of access into the network. This allows a user to view or change configuration options without the need to be at the facility. Highly cost-effective and very reliable systems are thus available from the telephone company equipment suppliers. Agencies often utilize the voice capability of a SONET system to implement PBX-to-PBX links between various locations, and to bypass the telephone companies to reduce their long distance charges. This option is a particularly valuable consideration when reviewing the installation of fiber optic cable between major metropolitan areas.

### 3. Fiber Optic Network Configurations

There are three basic network configurations, or topologies, that are used to design fiber optic systems: Star, Bus, and Ring.

*a. Star Configuration*

In a star configuration, separate fiber optic trunks are used to connect the communications hubs to the central facility. At each hub, connections are made to the field devices through a local distribution network which can consist of several diierent types of media, such as fiber optic cables, twisted pair, or radio based communications. The data to and from the central facility is multiplexed and demultiplexed at the communications hub.

This type of configuration has a disadvantage in that separate "home runs" are required from each hub to the central facility, and that it is typically not configured with redundant, automatic switch-over, fibers or equipment. This has the potential of being a single point of failure that could disable an entire hub. However, this is a proven system and has been successfully used in many traffic management systems.

*b. Bus Configuration*

In a bus configuration each communications unit, which may be a device located at a node or communications hub, or a field device such as a 170 controller, is connected to a fiber optic link or series of fibers carrying data in two directions, i.e., full duplex. Every device connected on the bus is assigned a channel and an address. Each device is accessed by polling it on its assigned channel, using the specified address, to retrieve data in the device and to send it control information. This bus configuration is commonly used in local area networks (LANs) used to link together personal computers.

The advantage of a linear or bus configuration is the use of a single communications link reaching from the central location to each field device. Low cost multimode fiber optic modems that are directly compatible with 170 controllers, VMSs, and related equipment are becoming available. The major disadvantage with this configuration is that a blockage in communication on the circuit can result from a single device failure. One manufacturer has added a battery backup to allow continued communication with downstream devices in the event of local power failure.

*c. Ring Configuration*

Ring configurations can be implemented as either a single ring, or as a dual (redundant) ring. Most ring configurations being installed today utilize a dual ring to take advantage of automatic reconfiguration, or self-healing capability of the system. This fault-tolerant approach significantly increases system reliability.

The operational advantages of self-healing rings are clear. Because this configuration is being widely implemented and utilized, a full range of equipment at competitive prices is readily available. The disadvantages are the requirement for additional fibers, and redundant equipment at the communications nodes. However, the incremental costs of additional fibers within the same cable is very small (approximately $150 per fiber per kilometer). Similarly, the incremental costs of redundant equipment, when compared to the life-cycle cost of system failures is again quite small.

## E. Available Communication Options

The two major alternatives for ATMS communications are leased and owned circuits. Some systems utilize a mixture of options; based on implementation timeframe, costs and other requirements. In this section, an overview of the various types of service available from commercial sources and applicable owned infrastructure are examined.

### 1. Leased Commercial Communications Circuits

The local telephone company, cellular carriers, and other communications service suppliers provide a variety of circuits operating at a wide range of speeds. Initial installation costs and short term monthly costs for low speed data circuits are low, and are thus advantageous for vehicle detection and variable message sign circuits. This assumes the availability of the physical connection near the equipment. There is a potential for additional costs when it is necessary to bury a service drop (probably in conduit) of a few pairs of wire that may run several hundred feet. Maintenance and repair is provided by the commercial service provider, removing the requirement for special training or equipment within an agency. The drawback of this arrangement is the “finger pointing” that often occurs when multiple parties are involved. The primary disadvantages are the long term costs (i.e., recurring monthly billings), and the expense of high speed circuits. Since the monthly costs are considered operational expenses, they must be budgeted from annual operations budgets and are thus often more difficult to obtain than initial capital funds.

Commercial communications circuits are available as either switched (dial-up) or dedicated (private line) facilities. Each of these basic types can be configured as point-to-point (2 parties) or multi-point (3 or more parties) circuits. For dial-up service, a multi-point circuit is usually referred to as a “conference call”. For dedicated circuits, the term multi-drop circuit is often used interchangeably with multi-point. A further distinction is the transmission technique used: analog or digital. The original telephone network was designed as an analog system for the transmission of voice. The availability of low-cost, high-performance computer circuits has allowed the telephone system to convert much of its transmission and switching equipment to digital technologies, resulting in better quality and performance at reduced cost.

Pricing of commercial circuits typically involves a one-time installation charge, and a recurring monthly charge. Circuits can be obtained on a month-by-month basis, or on various contractual terms ranging from 1 year to 10 years. Month-by-month service provides the most flexibility since service can be terminated when required, but it is the most expensive option. Multi-year contracts provide lower monthly costs, but include penalties for cancellation prior to the end of the contract period.

Dedicated circuits typically include three cost components in both the installation and monthly charge: the channel from the customer's premises to the telephone company central office, the channel that connects one central office to another, and the interconnection (or bridging) of the multiple parts of the circuit. Because of the complexities associated with the specific central office that provides each element of a particular circuit, and the mileage between the central offices, it is not possible to provide exact circuit costs until the specific locations of the traffic operations center (TOC) and the field equipment is determined. However! reasonable assumptions regarding service locations and inter-office mileage can be utilized to develop estimates.

For a pricing comparison of dedicated circuits, two typical configurations will be utilized in the following discussions. The first circuit is a point-to-point circuit originating at the TOC, running from the TOC to central office A, then 5 miles on an inter-office channel to central office B, and terminating at an item of field equipment (for example, a VMS or a CCTV camera). The second circuit is a multi-point circuit interconnecting four locations: the TOC and three items of field equipment (for example, model 170 controllers used to monitor traffic). The TOC and one of the 170s are served from central office A, the inter-office channel to central office B is 5 miles long, and the other two 170s are serviced from central office B. The cost estimates received from the telephone companies do not include any discounts for current service volumes, or existing special contracts. Thus, the following costs are conservative.

a. *Dial-up Analog Service*

This is the basic voice-grade telephone service provided for residences and businesses. These channels are provided to support voice communications, and are universally available. Currently available modems (modulator/demodulator) provide data transmission speeds in excess of 14.4 Kbps on dial-up phone lines. These units are inexpensive (under about $250), and widely available with numerous features and options. They are extensively used on personal computers for data and fax transmission, and well supported by commercially available PC software.

Dial-up telephone service is a useful alternative for occasional, relatively short-term data transmission. The dialing and connect time (15-30 seconds) does not realistically permit data collection or control of devices more frequently than every five minutes. The dial-up telephone network is designed and configured for human calling patterns and call holding periods, allowing the expensive central office equipment to be shared among many subscribers. Use of dial-up circuits for frequent data calls, or for long holding times, or for many hours of use per day, ties up the central office equipment and results in the local telephone company complaining about inappropriate usage.

The other concern with any dial-up configuration is security. The ability of "hackers" to break into computer systems has been widely reported, and cases of inappropriate or unsafe messages being displayed on VMSs through dial-up access have been documented. The use of dial-up/dial-back, encryption, security passwords, and other safeguards reduces the risk for these cases, but at the expense of increased system complexity and additional "hassle" for the personnel who have to support and maintain the system.

In the Rochester area, dial-up analog service costs $50.89 to install and $15.75 per month. There is a message unit charge for each local call that during business hours amounts to 7.6 cents for the first three minutes and 2.2 cents for each additional minute. Off-peak charges are 5.5 cents for the first three minutes and 1.5 cents per additional minute. One dial-up circuit is needed for each field device to be accessed, and one or more circuits are required at the TOC.

*b. Integrated Services Digital Network*

The technology for Integrated Services Digital Network (ISDN) was developed by the telephone industry during the early 1980s but has seen a very slow implementation. In the past three years, however, the penetration has increased significantly in many areas. The key benefit claimed for ISDN is the availability of 144 Kbps (divided into two 64 Kbps data channels and one 16 Kbps control channel) of switched digital data over two pairs of wires. Another benefit is the reduced switching/interconnect time, making it feasible to support more field devices on dial-up connections. There are two ISDN user offerings: the Basic Rate Interface (BRI), and the Primary Rate Interface (PRI). Basic rate ISDN is the digital equivalent of dial-up analog service. Primary rate ISDN is the equivalent of T-l service, it provides the user with 23 channels of 64 Kbps data and one control channel operating at 64 Kbps. Interface boards (equivalent to modems) for certain types of computers are coming down in price (into the $1000-$2000 range) and increasing in availability.

For the current generation of incident traffic management system equipment, utilization of ISDN circuits is probably not feasible due to the lack of interface boards for the equipment. Circuit availability is also a limiting factor. However, the next generation of equipment may well be able to take advantage of ISDN. Since

ISDN was developed as a digital service, its error characteristics and operational parameters will result in excellent performance. The current lack of interface boards, and limited availability of ISDN service limits the usefulness for current projects. Furthermore, since ISDN is basically a 'dial-up' service, its use for full-time channels, as typically used for traffic monitoring applications, may not be effective.

Video devices on the other hand are coming on the market with ISDN compliant interfaces. It may be feasible to utilize this technology to access remote cameras and transmit the video images to the TOC. The bandwidth available on a single BRI circuit is probably not enough for most applications to show traffic motion. Some manufacturers are providing inverse multiplexing capabilities in their equipment that obtains the required bandwidth from the inclusion of additional BRI data channels.

In Rochester, the installation charge for an ISDN BRI circuit is $151.89, and monthly charges are $25.40. These charges are applicable to each end of the ISDN circuit.

c. *Dedicated Voice Grade Analog Channels*

These circuits have been the back-bone of many traffic management and arterial control systems over the past twenty years. Modems to utilize these circuits are included in the design of 170 and NEMA equipment. They can be configured as either point-to-point or multi-point circuits, and can support speeds in excess of 9600 bps with current modem technology. There is a wide range of equipment available for interface to these channels. There are reports of telephone companies changing their tariffs and pricing policies to discourage use of these channels over the long term, in an attempt to move customers to digital channels. The primary advantages of these circuits is their wide-spread availability and their low cost for low speed circuits. Since these channels are designed for voice, they are not optimized for the transmission of data.

In Rochester, an analog point-to-point circuit, per the configuration described above, costs $113.89 to install, and $145.88 per month. A four drop multi-point data circuit costs $453.89 to install and $353.02 per month.

d. *Digital Data Channels*

The telephone companies offer a range of digital channels running from 2.4 Kbps to 64 Kbps. They are often referred to as DDS (DATAPHONE Digital Service) circuits. These circuits are primarily dedicated circuits, but are occasionally available in a switched configuration. A difficulty with these circuits is that they are usually configured as 'synchronous' data circuits, while most communications for incident/traffic management systems is 'asynchronous', requiring adapters at each end of the circuit. Since these channels are designed for data transmission, their reliability and operational characteristics are very good. The principle disadvantages are the fundamental 'synchronous' nature of the channels, and the limited availability of the Data/Channel Service Units (DSU/CSU) needed to connect to the circuits. Channel service units are generally required by the service provider. They allow remote loopback and isolation of installed equipment to facilitate testing of the channel. Data service units perform formatting of the customer data to the transmission format utilized on the carrier link. Costs for these devices run from about $350 where a minimum of data conversion is necessary, to over $1000 when speed changes and format conversions are necessary.

In Rochester, a digital 9600 bps point-to-point circuit (per the configuration above) costs $ 178.64 to install, and $258.18 per month. A four drop multi-point circuit costs $250.75 to install and $490.06 per month.

At 56 Kbps, a digital point-to-point circuit costs $178.64 to install, and $323.56 per month. For a four drop 56 Kbps circuit, the installation charge is $250.75 and the monthly charge is $602.28.

Another classification of DDS offered by Rochester Telephone is called A plus. This type of service requires the customer to use owned or leased data terminal unit (DTU) equipment on the circuit. The rates do not vary with the transmission speed or baud rate selected, but are fixed for the class of service. DTU equipment for each end of the circuit may be purchased from Rochester Telephone for $1680, leased on a 3-year basis for $60 per month, or leased on a 6-year basis for $40 per month. Given the configuration described earlier, installation costs would come to $215.89 and the monthly fee for the circuit would be $117.98. Maintenance for the DTU (if it was purchased from Rochester Telephone) is available at $7.50 per month.

*e.* *Digital Carrier*

In the mid-1960s, the telephone companies began converting their long-haul trunk circuits from analog technology to digital technology. The basic implementation was the DS 1 (Digital Service 1) channel, operating at 1.544 Mbps as shown in Table V-l. Note that this channel is commonly referred to as a T-l circuit. This T-l circuit is configured to support 24 voice grade channels, each requiring 64 Kbps of digital bandwidth. There is a hierarchy of faster digital circuits, each built upon various combinations of T-l circuits. A typical combination is DS3 (T-3) at 43.232 Mbps, or 672 voice grade channels. The emerging Synchronous Optical Network (SONET) standard builds upon DS3, and is defined in various combinations as high as OC-48 (Optical Carrier 48), which operates at 2,488 Mbps, or the equivalent of 32,256 voice grade channels.

Within the past few years, T-l service is becoming readily available to end users, driven by the demand for higher speed communications channels to link computers and local area networks together. The primary interest in T-l for traffic/incident management systems is digital transmission of video signals. T-l provides a reasonable option to agency owned fiber optic cable for a few circuits, and limited period of time, but quickly becomes quite expensive if large numbers of circuits are involved.

T-l service is only available in point-to-point configurations on a term contract of 12, 36, or 60 months. The local channel that runs from the telephone company central office to the TOC or equipment location is billed on a mileage basis, in 1/4 mile increments. For this cost estimate, it is assumed that the term is 12 months, the local channel at each end of the circuit is 2 miles long, and that the inter-office channel is 5 miles long. In Rochester, the installation cost of this circuit is $1283.89, and the monthly cost is $651.28. This provides the user with nine miles of service in our example.

## TABLE V-l

## SIGNAL BANDWIDTH

| DEVICE | Analog Bandwidth or Digital Rate |
|---|---|
| OC-48 Fiber Optic Data Rate | 2488.32 Mbps |
| OC-12 Fiber Optic Data Rate | 622.08 Mbps |
| OC-3 Fiber Optic Data Rate | 155.52 Mbps |
| CCTV Video Image | 6 MHz or 100 Mbps |
| DS3 Video Codec | 44.7 Mbps |
| DS1 Video Codec | 1.54 Mbps |
| DS0 Diqital Voice Teleohone Channel | 64 Kbos |
| Rochester UTCS Communication Rate | 56 Kbps |
| Voice Grade Telephone Channel | 4 KHz |
| VMS Communication Link | 1.2 Kbps to 9.6 Kbps |
| R Meter Communication Link | 1.2 Kbps to 9.6 Kbps |
| Detector Station Communication Link | 1.2 Kbps to 9.6 Kbps |
| Camera Control Communication Link | 1.2 Kbos to 9.6 Kbos |

*f.* *Cellular Telephone*

Cellular telephones have rapidly expanded their market penetration over the past five years, pushed by the convenience and declining prices. The cellular telephone network now covers over 93% of the U.S. population. Off-the-shelf cellular modems permit the transmission of data over the cellular network. The use of cellular telephones by field personnel has simplified many maintenance and incident response procedures. Note however, that cellular modems utilize different techniques for error correction and circuit initialization, and thus are often not compatible with landline modems.

The ready availability of service and capability to locate equipment anywhere within the coverage area provides a high degree of flexibility, especially for temporary installations, and portable or mobile equipment. Cellular equipment eliminates the need to connect to a telephone company service point. This capability of establishing a circuit on an as needed basis may prove cost effective for infrequent communications.

The primary disadvantage of cellular service is the pervasive fraudulent cloning that presently exists in metropolitan areas with large numbers of cellular telephones. This activity has resulted many thousands of dollars in long distance charges being billed to equipment that never originates a call. Service providers have cooperated when billing resulting from these fraudulent cloning operations is discovered, but the annoyance to the agency begins to outweigh the convenience of cellular service.

Another important disadvantage is the cost of the service itself Each cellular "telephone" incurs a monthly service charge ranging from roughly $15 to $45 per month, and a per-minute "airtime" charge ranging from $0.10 to $0.50 per minute. Due to competition, increasing numbers of users and the resulting additional volume, prices are falling. These price decreases are being driven by reduced unit cost reductions and "innovative" service plans. Rochester Tel Mobile offers plans with blocks of expected usage that range from 30 to 600 minutes of airtime. A plan with 60 minutes of "free" airtime costs $42.95 per month and 37 to 21 cents per minute for additional minutes. A scheduled usage of 300 minutes costs $95.95 per month and 30 to 17 cents per minute for additional minutes. However, even if costs were as low as 10 cents per minute, airtime costs $144 per day, making full-time cellular communications prohibitively expensive.

Since the existing cellular network utilizes analog transmission, it is somewhat noisy and thus limits the speed of data transmission. Cellular One has proposed a new service called Data Gateway that will allow data calls at 3 cents a minute during off-peak hours, regardless of volume. Buffalo Telephone markets Cellular One in the upstate New York area. Current charges for voice service by Buffalo Telephone are 21.5 cents per minute for voice connections by corporations buying

10,000 minutes or more airtime per month. The Data Gateway service costs $4.95 per month in addition to voice charges and usage fees.

Cellular telephones have been used by drivers to report incidents. Various agencies and municipalities have set up specialized “no charge” telephone numbers with the cellular providers for this purpose. An agreement with all providers in the region must be negotiated. Each cellular region has two providers. Agencies that utilize this type of arrangement report rapid notification of incidents with verification and additional details provided by multiple callers. Some providers of cellular service are experimenting with an offering called Cellular Digital Packet Data (CDPD). This offering may prove useful for transmission of data more economically than can be provided by normal cellular telephone. Even with CDPD, costs of cellular transmission are much higher than standard telephone connections. Cellular data transmission should be limited to interim operation.

g. *Packet Radio*

Packet radio is a wireless technique that is designed specifically for the transmission of data. Commercial suppliers utilize radio base stations to communicate with multiple field transceivers via time synchronized bursts, or packets, of data. Since many field transceivers share the same frequency pair for transmitting and receiving data, a cooperation strategy (or communications protocol) is utilized to coordinate this sharing. Because of this sharing, there can be delays of several seconds in delivering a packet. The pricing structure of packet radio is based upon amount of data transmitted, measured either in bytes or packets. This pricing structure, and the basic architecture of packet radio, is most effective when transmitting short bursty messages, and not large quantities of data. Typical prices are $0.03 per 100 bytes transmitted, which results in a cost of about $5.00 per hour for real-time communications with a traffic monitoring processor. This cost is prohibitive for continuous communications, but may be attractive for occasional use to some remote VMS and weather station controllers that would have been reached by cellular telephone. Considerable development may be required to convert the remote device and central processor to communicate in packet network protocol.

h. *Satellite*

Satellite communications services have been available for many years, and have proven cost effective for long-distance point-to-point circuits and for wide-area broadcast applications. However, for “local” applications (distances less than a few hundred miles), the costs of ground stations and satellite transponder rentals are prohibitive for traffic management applications. A typical monthly cost for a 56 Kbps circuit is $10,000; however, this is essentially independent of circuit distance, with a 200 or 2000 mile circuit costing the same.

The one case where satellite communications has proven useful for traffic management is incident response in rural areas. The ability to deploy an incident response vehicle, with voice, data and limited-motion video communications to a central control facility, has proven effective in field trials. The flexibility of this approach is a significant benefit, but the cost needs to be weighed against other communications channels.

## 2. Owned Infrastructure

In an effort to reduce monthly operating costs, and to provide the communications bandwidth needed for large numbers of video cameras, many agencies install their own communications facilities, For cable based land line systems, the cable and electronics are moderately priced; but the cost of trenching, installing conduits and ducts, backfilling and patching is significant. Depending upon construction conditions, conduit installation costs can range from $20/foot to $40/foot. This translates to $l00,000-$200,000 per mile. If structures need to be crossed, if roads must be bored under, etc. these costs can even be higher. The cable, installation costs, splicing, and electronics termination equipment costs from $5/foot to $l5/foot, depending upon the specifics of the installation. Maintenance responsibility becomes an important factor when a large communication plant is owned by the Department. Costs for maintenance are often estimated as 10 percent of the equipment costs. This figure can rapidly become large when dealing with a facility that is valued at several million dollars. On the other hand, leased service is maintained by the supplier, without additional charge to the user.

### *a. Twisted Wire Pairs (TWP)*

Twisted pair transmission of signals for communications has been the most common technology used for traffic control systems over the past twenty-five years. Twisted pairs of copper wires are commonly used to provide a voice grade analog channel. With appropriate equalizing circuitry, even video signals can be transmitted up to five miles on twisted pair cables, but fiber is preferred for signals of this bandwidth. The twist provided to the insulated conductors tends to cancel outside interference. Overall shielding further protects the pairs from induced noise that may come from lightning, nearby power lines or electrical equipment. Lightning however remains a problem, as surges can damage expensive equipment and reduce system availability.

Twisted pair cable has been the backbone of “the last mile” in communications systems for decades. It provides a simple, straightforward and low cost method for the short haul circuits from the termination of high capacity back-bone (long haul) circuits to the individual Vehicle Detector cabinets or Variable Message Signs. Twisted pair works well for speeds up to 9600 bps for distances of several miles. It has been installed in combination with a fiber optic long-haul system to interconnect the field equipment to the communications hub.

b. *Coaxial Cable*

Transmission of signals on coaxial cables for video and data was a standard technique for many years. It is fairly low in cost and easy to install. It is primarily used for 'short haul' transmissions. Broadband systems capable of 300 MHz utilize multiplexing to transmit many channels of video on a single cable. In general, since fiber optic cable has become available, coaxial cable has fallen in popularity.

There are, however, significant disadvantages to the use of coaxial cable. Coaxial cable systems, like those that have traditionally been used for cable television, require amplifiers spaced roughly every 1,500 feet. The amplifiers restore signal strength that is lost by attenuation in the cable. Any system that requires a large number of distributed active components, will be faced with a heavy maintenance burden. Additionally, when fittings are poorly installed or connections degraded by corrosion, coaxial cable can be subject to interference from electromagnetic and radio frequency sources.

c. *Fiber Optics*

Fiber optic cable is being installed in all new communications systems used for incident/traffic management. Fiber optic cables provide very high data rates (2.5 Gbps) over long distances (over 25 miles) without amplification. Other advantages are the small cable diameters (a 0.5" cable can contain 72 fibers), immunity from electrical interference, and avoidance of ground loop and lightning strike problems encountered with metallic conductors. Of course, a fiber optic line with metallic strength members is not lightning proof

Fiber optic cable is commonly manufactured with two internal structures: those fibers that support single mode transmission and those that support multi mode transmission. Single mode fibers are usually used for long-haul circuits that are longer than a few miles, but require more expensive transmission and receiving equipment to take advantage of its higher performance characteristics. Multi mode fibers are typically used to transmit video images a short distance from the CCTV camera to a communications hub that is at most a few miles away, where the images are combined, or multiplexed, onto a long haul single mode fiber for transmission to the control center. Multimode fiber utilizes lower cost transmission and reception equipment, but has a more limited range for bandwidth and distance.

Fiber optic cables have now become the primary medium utilized for transmission of high volume, high speed communications. Signals are transmitted through the core of a glass fiber. (The entire fiber is thinner than a human hair.) Internal reflections at the cladding layer, also made of glass but with a different coefficient of refraction, keep the transmission within the core of the fiber. A protective coating, made of a plastic material is applied to the outside of the fiber to provide increased abrasion protection and color code identification.

Fiber optic cables that are intended for long runs are usually manufactured with loose-tube construction. This type of fabrication allows the fibers to move within the buffer tubes and decouples the optical fibers from mechanical forces on the cable. Loose-tube fabrication reduces the risk of damage to the fibers during installation and temperature cycles.

Another cable type, called tight-buffered is also available. With this type of cable, the optical fibers remain coupled to external mechanical forces. This results in reduced pulling strength and temperature range for tight buffered cable. These cables are usually used for indoor applications.

Cables are available in both single mode and multimode forms. Multimode fiber has a large core diameter (probably the most commonly used at present is 62.5 microns) and is thus able to collect and accept more light from a source than the smaller core, single mode fiber. The many paths that light rays can take within multimode fiber (called modes) tend to produce dispersion or spreading of transmitted pulses. This is the result of some paths on which the light travels are longer than others, so all the transmitted light doesn't arrive at the receiver at the same time. A special graded index core-to-cladding interface can be used to limit the number of modes available in multimode fiber. Graded index fiber provides better performance characteristics than step index fiber.

Multimode fibers are presently available in three common sizes, 50/125 (core/cladding) microns, 62.5/125 microns,and 100/140 microns. Many industrial users and standards organizations, including the EIA/TIA are attempting to standardize on 62.5/125 micron fiber, when multimode use is required. This fiber size allows maximum connectivity, and offers an excellent range of attenuation and bandwidth.

Multimode fibers are available with large transmission bandwidth factors in the range of 1000 MHz km on 50 micron fiber at 1300 nm. This means that when using a 1300 nm transmitter, a transmission of a 10 MHz signal can go as far as 100 km (62 miles) before pulse spreading becomes intolerable. A transmission bandwidth factor of 1000 MHz km also means that 100 MHZ signal could only be carried for 10 km, while a 1000 MHz signal could only be carried 1 km.

Most multimode fibers have a transmission bandwidth factor of 160 to 200 at 850 nm This would allow a transmission distance of under 10 miles at 10 MHz using a 850 nm transmitter.

Attenuation must also be considered in the design of a fiber optic system. Losses of 3 dB per km at 850 nm and 1 dB per km at 1300 nm, are fairly common characteristics. Losses at splices and connectors should also be considered. (A good splice should produce less than 0.1 dB of loss and a connection should produce less than 0.5 dB.)

Low cost LED sources can be utilized for short range communication in the 850 nm window. Recent advances have resulted in LED sources able to transmit in the 1300 nm window, taking advantage of lower attenuation losses, but these devices are somewhat more expensive than the traditional 850 nm devices. Laser transmission sources for either window are the most expensive. A laser diode transmitter and receiver pair from one manufacturer is priced at about $2250, while a 850 nm LED system is about $950, and a 1300 nm LED system is priced at about $1700.

Transmission power and receiver sensitivity compensate for attenuation losses. The combination of equipment factors related to optical communication is specified in an optical loss budget for a transmitter-receiver pair. Although optical loss budgets are often in the range of 10 to 15 dB for many products, loss budgets above 30 dB can be achieved in some devices.

Single mode fiber has a small core diameter (typically 8 to 10 microns). The cladding diameter is usually a standard 125 microns. The small core diameter supports only one mode of propagation. Single mode fiber has a lower attenuation factor than multimode fiber, allowing a longer span without signal regeneration. Depending on electronics and the number and quality of splices, span distances of over 40 miles, without amplifiers or repeaters can be achieved. Single mode fiber is the preferred medium for transmission of high bandwidth signals for long distances. The electronics required for single mode fiber are presently more expensive than those required for multimode transmission. A single mode transmitter can be equipped with either a laser diode (LD) or edge emitting LED (E-LED). LD transmitters are preferred as they are more powerful and cleaner sources of monochromatic light, but may have operation temperature limitations. Since modal dispersion is not a problem in single mode fiber, long transmission distances cause other effects to become pronounced. Dispersion of light rays also occurs as a result of light frequency. Light from a source that produces a range of frequencies, as would be produced by an LED, travels in a range of different speeds in optical fibers. Chromatic dispersion pulse spreading results from this non-uniform arrival of transmitted light at the receiver. All factors relating to the characteristics of transmission must be considered in the design of fiber optic cable systems.

In general, single mode transmission is preferred as it offers a medium that is subject to fewer constraints and can provide long distance transmission of signals without a need for distributed signal amplification or regeneration. Costs for single mode fiber have recently dropped below multimode fiber as larger sources of supply are being formed on the basis of anticipated increases in demand. Single mode equipment costs are also falling as new technologies are introduced to replace expensive components.

Few standards exist for inter-operability of fiber optic modems since they are usually not connected on public switched communication systems. Generally, all modems used on a fiber optic cable must be provided by the same manufacturer, causing that manufacturer to become a sole source for replacement devices.

Fiber wiring practices should be carefully controlled. Bends and splices must be arranged without producing macrobend losses that can block proper fiber optic transmission. A fiber system that operates properly in one window may not perform well in the second window when poor practices are followed.

d. *Microwave*

Point-to-point microwave is an attractive alternative for initial, or limited usage, transmission of video images from CCTV cameras. For those cases where it is neither technically feasible, nor cost effective to install communication infrastructure, microwave can be utilized. Depending upon performance, a microwave system (transmitter and receiver, usually with a reverse direction control channel) for video transmission costs from $20,000 to $40,000. This equipment is very useful in the initial stages of system implementation, before a fiber optic system can be installed. As the fiber optic system is installed, the microwave equipment can then be re-used to extend CCTV coverage out beyond the end of the fiber optic network. A key limitation of microwave is the requirement for line-of-sight. Another problem with microwave is its degradation under adverse weather (heavy rain, snow, etc.) conditions, with greater susceptibility as higher frequencies are used. A microwave installation must receive a license on a site by site basis from the FCC. Difficulty in frequency coordination due to the proximity of the international border with Canada and the increased transmission effect of Lake Ontario are additional problems.

e. *Wireless Video*

A recent development in video transmission equipment is wireless video. This equipment transmits full motion video over a radio connection, in a manner similar to that used by microwave - but without the stringent installation requirements. Wireless video does require line-of-sight, but antennas are much less sensitive to alignment. Wireless video also does not require the licenses needed for microwave, because the equipment is class licensed by the manufacturer.

f. *Spread Spectrum Radio*

Spread spectrum radio transmission was developed nearly 50 years ago by the military as a security measure. These techniques were commercialized starting in 1985 when the FCC assigned frequency bands to spread spectrum radio. The technology spreads the signal bandwidth over a wide range of frequencies at the transmitter. The receiver knows the technique (or coding) utilized, and is thus able to recover the transmitted signal and reconstruct the original message.

Because each communications circuit within a given band utilizes a different coding technique, multiple, simultaneous circuits can co-exist. Spread spectrum generally requires line-of-sight, limiting its range to about 6 miles. The signal is attenuated by vegetation, so a site survey is recommended before committing to this technology. Field equipment can be placed anywhere within the range of a base station, thus very flexible installations can be developed. The basic technique of spreading the transmitted signal over multiple frequencies results in high noise immunity. The FCC has assigned the 902-928 MHz band for which no facilities license is required. However, spread spectrum equipment operating in this band cannot interfere with licensed equipment, and must accept interference from licensed services.

For traffic management applications, there is significant potential for spread spectrum radio. The work that is currently under way to evaluate spread spectrum for the next generation of digital cellular telephony may result in a wide spread application of the technology. If this occurs, there will be an increased availability of equipment and resultant price reductions. However, the technological complications will result in increased personnel training and specialization, and more sophisticated equipment.

## F. Implementation Options

As shown in Figure V-6, various devices or assets will be distributed along the highways included in the ATMS. Communication between the traffic operations center and each device can be provided by use of various alternative options that are discussed in this section.

### 1. Direct Connection

The first option to be examined is the direct (star) connection of each field device to a fiber optic cable. This option is illustrated in Figure V-7. The cost of this mode of connection is high as each field device operates on an individual fiber. Some combination of functions, in the intent of cost reduction, was performed on camera control. A multiplexed system is used to provide commands to camera groups. (A similar cost system could be structured with fiber video transmitters that utilize a reverse channel for camera control. The reverse channel is implemented in the same fiber that is used to transmit the CCTV video.) Separate transmitters and receivers are needed to connect each single mode fiber to the distributed field devices. Data from Table V-2 shows the estimated cost of a 50 mile directly connected communication system to be $9.6 million for video and $2.9 million for data and voice, totaling $12.5 million. Table V-3 shows the total estimated cost for a 150 mile configuration is $60.1 million.

# TABLE V-2

## SYSTEM OPTION ESTIMATE

## 50 MILE TYPICAL SYSTEM (Costs in thousands of dollars)

| ITEM VIDEO: | COST ($K) | DIRECT | HUBBED | SONET | PARTNP |
|---|---|---|---|---|---|
| Single Mode Fiber / Mile | 0.5 | 1250 | 250 | 50 | Provided |
| SM Video Xmtr-Rcvr Pair | 6 | 300 | 60 | Included | Provided |
| Video Mux Pair | 30 | | 300 | | |
| Sonet Mux (Ea+1) | 70 | | | 770 | Provided |
| Multimode Fiber / Mile | 0.7 | | 350 | 350 | 350 |
| MM Video Xmtr-Rcvr Pair | 1 | | 50 | 50 | 50 |
| Conduit / Mile | 150 | 7500 | 7500 | 7500 | Provided |
| FO Pull+Splicing / Mile | 10 | 500 | 500 | 500 | Provided |
| Addl Cable Pull / Mile | 0.8 | | 40 | 40 | 40 |
| DS-3 Video Codec Pair | 15 | | | 150 | 150 |
| Central Video Switch | 30 | 30 | | | |
| Remote+Central Video Switch | 55 | | 55 | 55 | 55 |
| Node Facility | 10 | | 100 | 100 | Provided |
| TOTAL VIDEO | | $9.580 | $9.205 | $9.565 | $645 |

| ITEM AUDIO and DATA: | COST ($K) | DIRECT SM Dist | HUBBED MM Dist | HUBBED TWP Dist | SONET MM Dist | SONET TWP Dist |
|---|---|---|---|---|---|---|
| Single Mode Fiber / Mile | 0.5 | 2500 | 250 | 250 | Provided | Provided |
| SM Data Xmtr-Rcvr Pair | 4 | 400 | 40 | 40 | Included | Included |
| Multimode Fiber / Mile | 0.7 | | 700 | | 700 | |
| MM Data Xmtr-Rcvr Pair | 0.8 | | 80 | | 80 | |
| Twisted Pair Wire / Mile | 0.6 | | | 600 | | 600 |
| Additional Cable Pull / Mile | 0.8 | | | 40 | | 40 |
| Data Mux Pair | 16 | | 160 | 160 | | |
| Channel Bank Pair | 30 | | | | 300 | 300 |
| TOTAL DATA & AUDIO | | $2,900 | $1,230 | $1,090 | $1,080 | $940 |

SUMMARY OF SPECIFIC SYSTEM COSTS

| | VIDEO | DATA | TOTAL |
|---|---|---|---|
| DIRECT VIDEO, AUDIO and DATA | $9,580 | $2,900 | $2,480 |
| HUBBED VIDEO, AUDIO and DATA | $9,205 | $1,090 | $10,295 |
| DIRECT VIDEO, MULTIPLEXED DATA | $9,580 | $900 | $10,480 |
| SONET VIDEO, AUDIO and DATA | $9,565 | $940 | $, o, |
| SONET PARTNERSHIP | $645 | $940 | $1,585 |

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# TABLE V-3

## SYSTEM OPTION ESTIMATE

## 150 MILE TYPICAL SYSTEM (Costs in thousands of dollars)

| ITEM<br>VIDEO: | COST ($K) | DIRECT | HUBBED | SONET | PARTNP |
|---|---|---|---|---|---|
| Single Mode Fiber / Mile | 0.5 | 11250 | 750 | 150 | Provided |
| SM Video Xmtr-Rcvr Pair | 6 | 900 | 180 | Included | Provided |
| Video Mux Pair | 30 | | 900 | | |
| Sonet Mux (Ea+1) | 70 | | | 2170 | Provided |
| Multimode Fiber / Mile | 0.7 | | 1050 | 1050 | 1050 |
| MM Video Xmtr-Rcvr Pair | 1 | | 150 | 150 | 150 |
| Conduit / Mile | 150 | 22500 | 22500 | 22500 | Provided |
| FO Pull+Splicing / Mile | 10 | 1500 | 1500 | 1500 | Provided |
| Addl Cable Pull / Mile | 0.8 | | 120 | 120 | 120 |
| DS-3 Video Codec Pair | 15 | | | 450 | 450 |
| Central Video Switch | 30 | 270 | | | |
| Remote+Central Video Switch | 55 | | 4951 | 4951 | 495 |
| Node Facility | 10 | | 300 | 300 | Provided |
| TOTAL VIDEO | | $36,420 | $27,945 | $28,885 | $2,265 |

| ITEM<br>AUDIO and DATA: | COST ($K) | DIRECT<br>SM Dist | HUBBED<br>MM Dist | HUBBED<br>TWP Dist | SONET<br>MM Dist | SONET<br>TWP Dist |
|---|---|---|---|---|---|---|
| Single Mode Fiber / Mile | 0.5 | 22500 | 2250 | 2250 | Provided | Provided |
| SM Data Xmtr-Rcvr Pair | 4 | 1200 | 120 | 120 | Included | Included |
| Multimode Fiber / Mile | 0.7 | | 2100 | | 2100 | |
| MM Data Xmtr-Rcvr Pair | 0.8 | | 240 | | 240 | |
| Twisted Pair Wire / Mile | 0.6 | | | 1800 | | 1800 |
| Additional Cable Pull / Mile | 0.8 | | | 120 | | 120 |
| Data Mux Pair | 16 | | 480 | 480 | | |
| Channel Bank Pair | 30 | | | | 900 | 900 |
| TOTAL DATA & AUDIO | | $23.700 | $5.190 | $4.770 | $3.240 | $2.820 |

SUMMARY OF SPECIFIC SYSTEM COSTS

| | VIDEO | DATA | TOTAL |
|---|---|---|---|
| DIRECT VIDEO, AUDIO and DATA | $36,420 | $23,700 | $60,120 |
| HUBBED VIDEO. AUDIO and DATA | $27,945 | $4,770 | $32,715 |
| DIRECT VIDEO, MULTIPLEXED DATA | $36,420 | | $42,120 |
| SONET VIDEO, AUDIO and DATA | $28,885 | $2,820 | $31, 705 |
| SONET PARTNERSHIP | $2,265 | $2,820 | $5,085 |

### 2. Hubbed Connection

When multiple 'local' signals are consolidated at hub locations, they can be transmitted in an 'express' fashion to the control center. An illustration of this technique is provided in Figure V-S. A 'local' distribution system, compatible with the short range communication system is used to connect individual field devices. The 'express' portion of the system is linked by single mode fiber to the TOC. Data from Table V-2 shows the estimated cost of this configuration for a 50 mile system to be $9.2 million for video and $1.2 million for data and voice for a total of $10.4 million. It would appear that this configuration offers the least expensive means of communication, apart from a partnership with a communication provider. For a 50 mile system, this is the case. As the system is expanded to the full 150 mile configuration, the cost trade-offs are shifted in another direction. Table V-3 shows that larger cost savings can be obtained with SONET communication. The cost for a 150 mile hubbed system in Table V-3 is $33.1 million.

### 3. Multiplexed Connection

Instead of originating at hubs, signals that are designated for equipment groups can originate from the head-end at the TOC. This form of consolidation offers the benefits of hubbed connection to reduce the fiber count of the transmission cables without requirements for a hub facility. An illustration of the interconnections utilized in this technique are provided in Figure V-9.

A cost estimate for multiplexed connection can be developed by adding video and data cost estimates for direct connection and subtracting 80% of the data fiber cost. The results of this calculation with data from Table V-2 shows the estimated cost of multiplexed connection to be $9.6 million for video and $2.9 million for data subtracting 80% of the fiber cost, or $2.0 million, results in a total of $10.5 million. Similar computations for the fully expanded system in Table V-3 shows a total of $42.1 million.

*a. Video Compression*

Various types of video compression have been used to reduce the bandwidth of video signals. Generally, lower bandwidth signals require less costly transmission facilities than do higher bandwidth signals. The quality (resolution) of the image and frequency of image update (refresh rate) to provide the appearance of motion however, both become factors in the reduction of video bandwidth.

Full motion video with standard broadcast quality utilizes a 6 MHz channel. Pictures that are updated every 15 seconds with somewhat lower quality can be transmitted on much lower bandwidth voice grade channels. Voice grade channels utilize only 4 KHz. This is a bandwidth reduction factor of over 1,000, Transmission of video snapshots may be necessary as an interim solution to provide video during construction, before the final communication system is ready.

It is expected that few cameras will be located far from interchanges. In most cases, cameras will be installed to allow verification of conditions on the cross streets before traffic is diverted to them. Fiber optic connections between cameras and communication equipment are recommended to avoid lightning and ground loop problems that often trouble metal cabled systems.

### 4. SONET Connection

The use of equipment that has been developed for the telecommunications industry offers some distinct advantages. The possibility of rapid obsolescence is decreased as the equipment has extensive deployment and a large powerful customer base. The advantage of redundancy can be utilized in the use of ring topology. An illustration of ring topology automatic reconfiguration after a communication disruption is illustrated in Figure V-10. With counter-rotating ring topology, redundancy is provided without the need for additional fibers or alternate paths. An alternate path is formed by re-direction of signals around the ring in the other direction to bypass a fault. Automatic switching to alternate routes and notification of detected faults has been engineered into the equipment. The cost of SONET features is high, but less than direct connection. Data from Table V-2 provides an estimate of these costs. For a 50 mile SONET system, with twisted pair distribution, the estimate for SONET connection is $9.6 million for video and $1.2 million for data, totaling $10.8 million. When the system is fully expanded as shown in Table V-3, apart from partnership, SONET becomes the least costly option at $32.6 million. The advantages of an all fiber system outweigh the slight cost advantage of twisted pair distribution. The savings by avoidance of problems that result from ground loops and lightning are well worth an increase of less than 10 percent of the audio/data cost.

### 5. Public/Private Partnership

The last option examined involves innovative use of existing assets. The partnering concept is described in the Available Communication Options section of this memorandum. Such a partnership would result in the provision of SONET communication channels, with access at communication hubs along the freeway. A separate local collection network and equipment to provide the required transmission format would still be required. Costs involved with this type of configuration are shown in Table V-2 in video partnership (PARTNP) and audio/data owned TWP distribution. This configuration is estimated at $0.6 million for video and $1.2 million for data and voice. The total cost comes to $1.8 million. Considerable savings are also available when the 150 mile, fully expanded system is considered. As shown in Table V-3, the costs for the full system are below $6 million. Again, the advantages of an all fiber system outweigh the slight cost advantage of twisted pair distribution. The savings by avoidance of problems that result from ground loops and lightning are well worth an increase of less than 10 percent of the audio/data cost.

## G. Partnership Opportunities

Some innovative public/private partnerships have recently been applied in the provision of communication services in exchange for easement of right-of-way to provide a path for communication cables along State and Interstate Highways. Projects employing this concept are being started in Kansas City and St. Louis, Missouri, the Garden State Parkway in New Jersey, and to share resources between agencies in Maryland.

### 1. St. Louis, MO

As part of the Bi-State St. Louis Area IVHS Planning Study, a communications partnership was developed between the Missouri Highway and Transportation Department and Digital Teleport, Inc. The intent of the Missouri Highway and Transportation Department (MI-ITD) was to develop a communications infrastructure for the St. Louis area, as well as a connection to Kansas City, along the interstate highway system in Missouri. The MHTD intended to allow access to the right-of-way along the freeway by the communications company and to have the communications infrastructure installed at no cost to the MHTD or the taxpayers. A Request for Proposal was developed by MHTD and circulated to 250 companies involved in communications; telephone companies, cable television companies, etc. Twenty-two (22) such companies attended the pre-bid conference.

There are approximately 210 miles of interstate highways in and around St. Louis and approximately 240 miles between St. Louis and Kansas City. There is a total of approximately 1250 miles of interstate in Missouri. The contract was set up as a package deal; all interstates were to be equipped with fiber optic cable, not just the rural areas between the two major cities.

Digital Teleport, Inc. (DTI) was the successful bidder on this project that provides a forty year exclusive right to DTI for placement of fiber optic cables along MHTD highways. In return for this exclusive right, six dedicated fiber optic strands will be provided for the exclusive use of MHTD for traffic management applications. A self-healing, collapsed SONET ring configuration was specified. MHTD has access to up to three DSl channels at each interchange node. All equipment to transmit the signals and maintain proper operation is the responsibility of DTI. This configuration requires MHTD to utilize costly DSl codecs (compared to DS3) to digitize video signals from each camera, assuming two per interchange. Relatively expensive DSUs (in comparison to low speed modems) are required between each highway device and the communications system to provide the 56 Kbps connectivity specified for that system. If this type of agreement can be negotiated for the Rochester area, care should be taken to minimize equipment and maintenance costs to the department.

The MHTD estimated that a contract for the installation of fiber would have cost MHTD approximately $45 million statewide; $22 million in St. Louis for 250 miles. A pair of fibers is capable of carrying 1,344 bi-directional voice grade circuits when operated with OC-48 SONET equipment. That pair of fibers could alternatively carry 48 DS3 video channels, or an appropriate combination of voice, data, and video at OC-48. The choice of 6 fibers was a guess on the part of the MHTD based on the use of multiplexing equipment to combine multiple CCTV cameras on each single-mode fiber. Also, there will be an algorithm employed to send only the visual signal from a CCTV camera that spots trouble on the freeway. There are plans for only 8 or 9 monitors in the Traffic Operations Center. DTI will install the fiber as well as SONET hubs and nodes at approximately 140 interchanges along the freeway. The 140 nodes are intended for MHTD's use only. The SONET hubs are for shared use. The contract is for 40 years with a possible 20 year extension. The fiber optic cable will be maintained by DTI.

Prior to this agreement, utilities were buried in designated rights-of-way called utility corridors, in areas where there are service roads along the freeways. Now, the fiber optic cable will be directly buried 20 to 30 feet from the edge of pavement of the roadway. An empty conduit will be buried along with the fiber optic cable. A minimum of 48 fibers will be buried with 6 dedicated to MHTD use.

The down side to this arrangement is that the MHTD must stay away from the fiber optic cable. The MHTD or any agency that damages the fiber optic cable is responsible for repairing or replacing the damaged section. Also, if the MHTD were to widen the road and infringe on the fiber optic cable then the MHTD would have to pay to relocate the cable.

### 2. New Jersey Highway Authority, Garden State Parkway

The Garden State Parkway has a partnership agreement in development with Bell Atlantic to provide a number of DS1 and DS3 channels between the various toll plazas and the Administration Building. Again no access to the fiber is granted, however alternate routing by automatic reconfiguration is to be provided by the communication carrier over routes that are available within their network, should there be a disruption of service.

### 3. Maryland Highway and Transportation Department

A project centered in the Baltimore area has been proposed as a public-private partnership to provide SONET facilities for a number of diverse Maryland agencies. The partnership with a communication provider would supply use of communications infrastructure in exchange for long term use of specific rights of way.

### 4. Rochester, NY

The Rochester ATMS is expected to ultimately cover approximately 100 miles of primary routes. The cost of installed conduit alone on this system has been estimated to be between $13 and $2 1 million. Under a partnership agreement, a communication provider would be permitted to install conduit and cables along certain roadways that will serve the provider's needs. The configuration would also provide the communication network required for ATMS, without the high dollar costs associated with installations of this type.

In the Rochester area, recent judicial decisions have permitted competition among various telephone companies to provide dial tone for telephone subscribers. This means that there should be an interest in gaining rights for communication cable placement by a number of communicationproviders.

Conduit for most of the downtown area has been obtained by MCDOT from RG&E under a 30-year agreement. Roughly 20 years remain under this contract. There have been problems with interference coming from high voltage cables in the same duct bank. The use of fiber optic cable will eliminate all interference that is generated by cable proximity as fiber optic cables are immune to this type of interference. Further investigation of the agreement will be necessary to determine if these grandfathered rights for use of RG&E conduit can be extended to include fiber optic cables placed by a public/private partnership for the County, similar to the arrangement proposed for ATMS communication.

## H. Recommendations

There is a clear cost advantage to develop a public/private partnership to provide video communication channels. This type of agreement can provide all the advantages of SONET communication without the high costs associated with a SONET implementation, were the communication system to be installed solely for the ATMS on the public side.

Capacity for multiple circuits able to carry both data and voice would be made available by connection of a channel bank. A channel bank is a multiplexer that connects twenty-four low speed voice grade lines to a DS l channel.

The physical connection to each low speed device can be made economically for short runs on multimode fiber. At somewhat higher cost, single mode fiber is being standardized upon by some agencies for all fiber communication, regardless of distance. Advantages of this strategy include less inventory to stock for spare parts and less chance for confusion in repair, maintenance and system expansion. Single mode fiber is generally preferred for communication because transmissions can generally be made over longer distances and are not degraded by pulse spreading dispersion. Other considerations come into play when long transmission distances are involved, but the problems have solutions.

At present, digital video can most cost effectively and economically be accommodated on DS3 channels, if they can be provided through public/private partnership, with no real dollar cost to the department. The cost of DS 1 codecs should however come down in the next few years and their application will result in more effective use of bandwidth, since a DS3 channel can carry 28 DS 1 channels

In general, specific recommendations should be delayed until it is found what type of public/private partnership can be structured. The communication necessary for ATMS can then be built into what becomes available, with owned infrastructure required only for the features that are not provided through the partnership.

### 1. Interim Operation - Wireless Communication

The implementation of an ATMS is expected to be in stages. The communications circuits utilized to support a staged implementation should rely first on those technologies that are easily deployed. As the final system hardware is positioned where necessary, the long term communications infrastructure can be implemented. Communications that rely on wireless technology such as packet radio and cellular telephone are the quickest and easiest to utilize as the technology is already in place. Dial telephone and leased lines involve a bit more installation commitment but are also quickly installed techniques. Owned facilities and transmission equipment for long term wide-band communications should be utilized where they can be shown to be cost effective.

Since completion of construction for the system may take several years, it is desirable to provide some benefits of ATMS operation as quickly as possible. Various traffic management functions can be achieved by use of portable equipment connected by wireless communication. CCTV cameras are available with range of a few kilometers, and provide full bandwidth, non-licensed, wireless transmission. Encoders that provide snapshot images can transmit by cellular telephone in less than a minute. Portable matrix signs can be controlled by use of cellular telephone, or even a digital pager network, at a remote site. The message on such a sign can be changed as conditions change, without the need for permanent telephone connection. The duration of the cellular call can be kept to a few seconds to keep air-time costs low. An ATMS can be configured to provide positive results before a complete infrastructure is available that supports full operation.

# CHAPTER VI

# MONROE COUNTY
# UTCS SYSTEM UPGRADE OPTIONS

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# VI. MONROE COUNTY UTCS SYSTEM UPGRADE OPTIONS

## A. Introduction

In order to interface with the proposed Advanced Transportation Management System and become part of a regional approach to transportation management, the computer system of the Monroe County UTCS / Zone Monitor System will likely need to be upgraded or replaced. After a detailed evaluation of the Monroe County UTCS, it was determined that there was various levels of upgrades that could be implemented. These levels range from increasing the current timing patterns to the replacement of the central hardware and software The implementation of these levels depends on the following:

1. Availability of funding

2. Long term goals of Monroe County

3. Available staffing for Monroe County

4. Location of the ATMS control center

## B. LEVEL 1 - Timing Plan Development

As part of an overall diversion plan development, as a minimum, there should be additional timing plans developed to accommodate a breakdown in the freeway system. During a freeway incident that causes a lane closure, the normal reaction of the responding emergency personnel is to release the freeway traffic onto the city streets. The current system has the technology today to respond to this type of incident in order to minimize the impact in the incident area. But, this also requires numerous engineering hours to analyze, develop, implement, and fine tune traffic signal timing plans for areas where the freeway system severs the surface street grids and arterials.

After these timing plans have been developed and implemented into the system they can be manually implemented upon notification of the incident. For example, if the ATMS system, system operator, or an external source “called in’ the notification of an incident, then the operator of the UTCS system could manually evaluate the location of the incident against the available tuning patterns that have been developed and implement the best plan for that time period. This is basically the method that is used today in the operation of the Monroe County UTCS. For normal operation, the current timing plans that are developed operate well, but for the “unforeseen incident”, significant engineering and timing plan development will be required.

This level of upgrade is only effective if the following is true:

1. The system is manned during the time of the incident, so the call can be received and the timing plans evaluated.

2. Sufficient timing plans have been developed to cover the potential incident areas.

3. The system operator is continuously being provided changing traffic information so that the selected timing plan can be changed to adapt to the new conditions.

This level of upgrade "alone" provides the least amount of effectiveness, but also requires the least amount of effort and the current system will support these timing plan changes without any hardware or software modifications. The implementation of this level does not preclude the implementation of any of the subsequent levels except those that include traffic adaptive algorithms.

The approximate cost for this level is about $900 per intersection to develop the timing/phasing plans. Not all of the intersections are candidates for this upgrade.

## C. LEVEL 2 - Remote Access

Currently, the system does not have any type of remote access that could be used for interrogating the system during off hours, weekends, holidays, or by maintenance personnel. This was a problem with the majority of the UTCS systems installed across the country, but it has been determined to be an invaluable asset to any operating and maintaining agency.

By expanding the current system to allow for remote access, the ATMS operator, maintenance personnel, police, or any external source could notify Monroe County of an incident and MCDOT personnel would not have to be present in the control center to respond to the request. This would be especially important in Rochester, due to the significant amount of snow and inclement weather that may delay the operators from arriving at the control center immediately.

This remote access should include a dial up from a laptop computer that provides all of the command and monitoring capabilities that are currently available to the operators in the control system.

This remote access would only be a significant benefit if the appropriate timing plans were available to activate. With every external interface to a control system, the appropriate security should be implemented on the dial up line to prevent unwanted access.

The approximate cost for implementing a remote access is approximately $12,000.

## D. LEVEL 3 - Traffic Responsive Control Operation

The current system is capable of operating in a traffic responsive mode. This means that the system gathers detector volumes and occupancy for numerous locations and compares this data with stored historical signature values to automatically determine the appropriate timing plan. Monroe County has unsuccessfully attempted to operate their system in this mode in the past, but has indicated that they had attempted to operate the entire system in this mode instead of specific arterials. It has been determined in numerous UTCS systems across the county that it requires good timing plan preparation and detector signature values to make the traffic responsive mode operate properly.

After the efforts have been implemented to develop timing plans that could accommodate an incident, the next step would be to develop the signature values for the system detectors and install them into the UTCS database for implementation. In a normal operation, the traffic responsive mode should look just like the Time Of Day operation. The system detectors would notify the system of the appropriate volumes and allow the system to select the plan that would have most likely been implemented by the engineer. It is only in an abnormal condition, should the traffic responsive mode select traffic patterns that are abnormal. This allows for the UTCS to begin to react to an incident prior to the system operators being notified, or if the system is not manned.

The approximate cost for developing the UTCS signature values is $30,000.

## E. LEVEL 4 - Direct Connection With ATMS

The next level upgrade for the UTCS would include a physical connection between the ATMS host computer and the UTCS. This would allow the ATMS host computer to determine the control section that has the incident and the level of incident and either automatically dial up the UTCS or be directly connected to transfer this information. After this is accomplished, the UTCS now has to react to this information.

The first task is to notify the UTCS operator of the incident with alarms and event messages, so the operator can be aware of the incident and take the appropriate action. The next task that the UTCS can perform is to use detector volumes that are provided by the link to the ATMS to operate that control section in a traffic responsive mode. This. has been tried in other UTCS systems and in most conditions has failed. The failure is normally attributed to the lack of timing plans for the traffic responsive algorithms to select and the inappropriate definition of detector signature values.

The interface with the ATMS computer would require a modem, a physical communication port on the Concurrent, and a task to be developed. This software task would perform all of the communicating between the processor and would provide the detector data to the traffic responsive algorithm for the desired control sections. This traffic responsive interface requires that the previous timing plan and signature levels have been implemented. The approximate cost is $23,000 for the direct connection to the ATMS.

This option is applicable if the system remains “as is” and also if the system is replaced with higher levels.

## F. LEVEL 5 - Central Communication Units

The current Tocom Central Communication Units (CCU’s) are tightly integrated into the Concurrent computer via a ULI interface. The CCU’s are specifically designed to support the coax system only. To expand the communications to the ATMS would require modification of these units or the addition of other types of CCU’s.

The next level of upgrade would allow for a fiber optic interface to the existing system. It has been determined that to support the data requirements for the majority of ITS technologies, that fiber optics is normally required. A fiber optic backbone would provide the bandwidth required to support any future expansion to the system.

This is best accomplished by leaving the existing CCU’s alone and add an additional CCU to communicate over the fiber optic link. The existing CCU’s are both operational and “one of a kind”. Any modification or enhancements would be risky to the operation of the existing system. Adding an additional new CCU would allow for a transition between the old coax communication plant and a new fiber optic communication plant. The interface with the central computer should use communication standards and not be proprietary. For example, using an ethernet link that communicates in TCP/IP packets. The new CCU should be of standard “off the shelf” hardware for maintainability. “Off the shelf” CCU’s are becoming more and more available. Some of these include VME processors and PC 486 mother boards with intelligent 1/0 cards. To provide an interface with a host computer, an ethernet adaptor has been used. This should also include a standard protocol such as TCP/IP. This would allow for a smooth integration of a future host computer regardless of the manufacturer.

This would also allow the current system and current software to operate as it has in the past over a fiber optic network without major modifications. The central software would communicate to both CCU’s once per second and use a database indication to determine which signals are associated with each CCU. This level of upgrade allows the existing system to basically stay in place and still allow the field communication plant to be upgraded to support future ITS technologies.

The approximate cost of the new CCU to support fiber optics and the modifications to the UTCS software is approximately $65,000.

## G. LEVEL 6 - Controller Enhancement

Currently, the system communicates to NEMA controllers through a RCU once per second. This method is still being used throughout the U.S. in new systems, but with the introduction of Type 170's, 179's, Advanced Traffic Controller (ATC's), and TS2's, some consideration should be given to upgrading the controllers.

If the central system is not upgraded, then any new controller should only have to emulate a NEMA controller. If the system is upgraded, then the new system should take advantage of the uploading and downloading capabilities of the new advanced controllers. The new system should be able to communicate with multiple controller types to allow for system flexibilty. The cost of this option depends on which new controllers are selected. Controller prices range from $1,000 - $2,800 each.

## H. LEVEL 7 - Central Hardware Replacement With Coaxial Communication Plant

The existing UTCS Concurrent hardware is 1970's technology and is basically outdated. The current system operates at about 700,000 instructions per second or about l/3 that of today's Pentium PC. This machine offered the best 32 bit performance during the time period that Monroe County's system was being designed, but there have been significant leaps made in computer technology in the past few years.

There are numerous UTCS systems operating on the same hardware platform as that of Monroe County. The majority of those systems are in the process of either upgrading the central hardware or designing a new type of system. The life expectancy of the existing central hardware is approximately another 5 to 8 years. When considering the long term usefulness of the existing hardware, the cost of maintenance of the existing hardware and the amount of expandability limitations of the existing hardware, the central computer hardware will need to be replaced if the system is expected to "take on" any additional ITS tasks. For cities that are not expanding and are not considering any ITS upgrades, this hardware could operate as it presently does for nearly ten more years.

Over the past 3 to 4 years, the majority of the traffic control system builders have ported their software off the Concurrent Computer platform and on to other hardware platforms that include DEC, PC's and Unix based processors (SUN , HP, etc.). This effort has occurred due to a variety of reasons that include the following:

1. Less expensive initial hardware costs
2. Less expensive annual hardware maintenance costs
3. Smaller footprint required for the hardware
4. Requires less air conditioning/power consumption
5. To stay on the leading edge of technology
6. The financial instability of Concurrent Computer Corp.
7. Long term system reliability
8. Availability of existing "custom" hardware

Considering the above reasons, and the long term expectations of this system, some consideration should be given to this level of upgrade.

Some of the proven hardware platforms that are candidates are DEC, PC's and Unix platform processors. All of these processors would provide the following general functions:

1. Small hardware platform
2. Over 10 times the current processing power
3. Network oriented
4. Redundant systems with a failover or standby processor
5. Supports "workstation oriented operation"
6. Supports large amount of commercial so&ware
7. Inexpensive to maintain
8. All have proven traffic signal control installations

Our recommendation for a central hardware upgrade would be to select from one of these platforms for the central host computers and combine these with a local area network with either PC or Unix workstations for the operator interface. The majority of all traffic systems that are being designed or implemented today or workstation oriented. The desire is for the traffic engineer to be able to perform the majority of his duties from his desk instead of always having to be located in the central computer room.

As a transition, the existing CCU's could be attached to the new system via a parallel interface and a new fiber CCU could be attached by using a more state of the art connection. This would allow a new central hardware platform to support the old communication plant and the new fiber optic communication plant.

The approximate cost for the replacement of the central computer hardware and to provide a local area network with workstations to support the traffic engineering functions would be between $200,000 and $265,000.

## I. LEVEL 8 - Central Software Replacement With Existing Communications Plant

The central software must be replaced if the central hardware is replaced. The software can be "ported" to the new host computer or the software can be completely replaced. Any replacement or major enhancement of the UTCS software is only feasible if the central computer hardware is replaced. The current central hardware is operating at or near capacity and does not have the the processing power required to *significantly add functionality to the system software.

This upgrade would be particularly important if the location of the ATMS were to be at the Monroe County facility 'or co-located with the Monroe County system in a different location. With the enhanced communication plant and available ITS information, the central software could have increased functionality, such as:

1. Collect and monitor various types of real time traffic data
2. Provide area-wide arterial surveillance and detection systems
3. Predict time and place of traffic congestion based on real time information
4. Implement traffic planning and management strategies that can respond to changing traffic flows and incidents in a timely fashion
5. Develop routing information
6. Integrate and manage transportation information and demand management

7. Develop real time adaptive control strategies that coordinate and control traffic across a number of intersections or areas using a global - local hierarchical control architecture.

The County has become accustomed to using a centralized system for control and monitoring of their traffic signals. With the extensive existing communication plant and facility available to them, this type of system provides the most capabilities.

As for the exact software package for the upgrade, there are multiple vendors that supply software that would be compatible with the new hardware mentioned above and that provide a state of the art software platform that would be necessary to expand with the new ITS technologies of the future This would also include variations of the UTCS that have been modified for the 1990's.

An upgraded UTCS software package would include, but not limited to the following:

1. Once per second monitoring of all intersections in the system
2. Capability of both distributed and central control
3. Capability of upload and download of controller parameters
4. Interface with various advanced traffic controllers (NEMA, 17Os, 179s, 207Os, etc.)
5. Support Commerical Off The Shelf (COTS) database management system using standard SQL calls.
6. Supports real time graphics of the entire system
7. Supports GIS interface
8. Supports integrated CCTV control and monitoring
9. Supports VMS from the central software
10. Supports the integration of traffic adaptive algorithms
11. Weather adaptation for control
12. On-line database installation
13. Support on line time space diagrams
14. Support diamond interchanges, lead/lag operation

15. Support high speed data transfer with ATMS system

16. Support critical event processing and dial up pagers for operators

17. Emergency vehicle preemption

18. Critical Intersection Control

19. Dynamic report generation

20. Remote workstation operation

21. The software should support a complete network operation that allows for any function to be accomplished from any workstation.

22. The existing closed loop system should be integrated into the central as if it were only one system.

The above software functionality can be provided by multiple software suppliers. It is critical that the central UTCS software is modular in nature and developed using the latest in software development techniques. It is also critical that all of the software source be provided to the owner to allow for expansion and modification for future ITS technologies.

The above software upgrade could be implemented on one of the recommended hardware platforms for $275,000 to $400,000 depending on the software vendor.

## J. Central System Replacement With New Communication Plant

As outlined previously, the existing communications plant is based on both outdated Central Communications Units, and RCU's. These items are "one of a kind" and expensive to maintain. In addition, the 55 miles of Coax cable is also difficult and expensive to maintain. Monroe County is unique in that they are one of the few jurisdictions that have been able to successfully maintain a Coax based communications plant. Unfortunately, this has required significant man hours and money.

If the communications plant were to be modified to either fiber optics, twisted pair or dial up lines, then the County would have more choices for the type of central system replacement. There are now numerous micro-based systems that support up to 32 intersections on a communications channel (fiber or twisted pair). Most of these systems also support dial up to controllers or field masters. Some of these systems are as follows:

1. JHK "System 2000"
2. Farradyne "Mist" System
3. Control Technologies "PLUS" and "OnTime" Systems
4. Sonex "Escort" System
5. Peek "MAT" System
6. Numerous Closed Loop architecture systems

All of these systems support "workstation oriented control" and could support a variety of new communication plants. The cost for one of these micro-based systems is approximately $225,000 - $400,000. This cost is comparable to the cost of replacing the existing central UTCS software, except it would support the replacement of the central coax communication plant. If the communication plant were to be replaced, the RCU's, controllers and cabinet wiring would also have to be significantly modified or replaced. This cost is directly related to the choice of communication plant that was chosen.

## K. Summary

The different levels of upgrade described above allow for some flexibility by which the existing UTCS can interface with the ATMS. At first, Monroe County may only choose to develop more timing plans and wait to upgrade the controllers and CCU's. Unfortunately, the existing system will need to be replaced in the next 5 to 8 years.

In summary, the above options provide the County with some possible direction in the maintenance and upgrade of the existing UTCS system. All of these options could provide an interface to an ATMS and establish a possible transition of upgrades for supporting new ITS technologies and providing better tools for the engineers at Monroe county.

**TABLE VI-1**
**COST SUMMARY**

| | | | |
|---|---|---|---|
| Level 1 | - | Timing Plan Development<br>250 Intersections @ $900 | $225,000.00 |
| Level 2 | - | Remote Access | $12,000.00 |
| Level 3 | - | Traffic Responsive Operation | $30,000.00 |
| Level 4 | - | Direct Connections to ATMS | $23,000.00 |
| Level 5 | - | Fiber CCU | $65,000.00 |
| Level 6 | - | Controller Upgrade<br>360 @ $1,000 - $2,800 * | $360,000.00<br>to<br>$ 1,008,000.00 |
| Level 7. | - | Central Hardware Replacements | $200,000.00<br>to<br>$265,000.00 |
| Level 8 | - | Central Software Replacements | $275,000.00 |
| | | | $400,000.00 |
| Level 9 | - | Central System Replacements | $225,000.00 |
| | | | $400,000.00 |

Options:

| | | |
|---|---|---|
| I. | Level 1 - 4 | $290,000.00 |
| **II.** | Level 4 - 8 | $1,148,000.00 |
| | | $2,161,000.00 |

- The exact number of intersections shall be determined by the diversion route requirements.

# CHAPTER VII

# STRATEGIC IMPLEMENTATION/ DEPLOYMENT PLAN

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# VII. STRATEGIC IMPLEMENTATION / DEPLOYMENT PLAN

# VII. STRATEGIC IMPLEMENTATION/DEPLOYMENT PLAN

## A. Introduction

### *1. Area of Coverage*

The expressway system within the Greater Rochester area has been the primary consideration in developing the Strategic Deployment Plan for an areawide Advanced Transportation Management System (ATMS). There are approximately 100 miles of expressway in the study area. The arterial network would provide the alternate routes for incident management and would thus need to be integrated into the total transportation plan. Approximately 100 miles of arterial routes have been analyzed within the study area. The Rochester-Genesee Regional Transportation Authority's (RGRTA) automatic vehicle location (AVL) system should also be integrated with the total transportation system. The New York State Police, Greater Rochester Interstate Patrol, have been considered for co-location within the New York State Department of Transportation (NYSDOT) Traffic Operation Center along with the Monroe County Department of Transportation (MCDOT) Traffic Control Center.

### *2. Agency Involvement*

The Technical Advisory Committee and the Incident Management Task Force formed during the process of this study are comprised of representatives of the NYSDOT as well as various transportation, emergency management and private sector agencies within Monroe County. These committees should continue to meet on a periodic basis to discuss the outcome of major incidents, to plan construction and maintenance activities, as well as to guide the planning and design process of the Advanced Transportation Management System, to deploy early action ATMS strategies set forth in this plan and to promote improved communications between emergency response and management agencies. The New York State Thruway Authority (NYSTA) has been contacted with the intentions for future coordination between the NYSTA and the ATMS agencies which will be necessary when equipment is deployed in the vicinity of the Thruway.

### *3. Legislative Changes*

A policy for leasing or utilizing public rights of way on the various interstate, state, county and city roads for communications companies to install communications infrastructure is in progress.

The development of a policy of quick removal of disabled vehicles is also in progress.

### 4. *Deployment Schedule*

*Near-Term* - Initial projects and/or actions which can be implemented within two years from the decision to proceed.

*Short-Term* - Projects and/or actions planned to be implemented in a time frame of two to five years from the decision to proceed.

*Medium-Term* - Projects and/or actions to be implemented in a five to ten year time frame from the decision to proceed.

*Long-Term* - Projects and/or actions to be implemented more than ten years into the future.

Figures VIII-l through VIII-4 have been prepared to illustrate essential equipment locations of VMS, CCTV and HAR; as well as to show the phase designations. Discussion of individual recommendations are presented below:

## B. Implementation Plan Recommendations:

The Monroe County 911 Center will be the relay point of communications for incident command, control and dispatch. The NYSDOT TOC/MCDOT TCC will increase their detection and surveillance capabilities to decrease the amount of time it takes to detect and verify an incident on the areawide roadway network. The TOC/TCC will provide the necessary information to the 911 Center. The TOC/TCC will manage the transportation network through traffic signal control, VMSs and HAR broadcasts in coordination with the 911 Center.

### 1. *Near-Term Implementation Plan, within 2 years:*

The following recommendations are designed to deliver the maximum benefit for the least amount of initial investment and to build a sound foundation for a future regional Advanced Transportation Management System.

It is necessary to implement such devices as the milepost/kilometer-post markers, landmark signs and route/direction designation signs and "Call 911" signs prior to developing the electronic deployment. The static signing provides the location designation for the existing operations of incident management. They provide information to the motorist for locating incidents as well as providing information to the traffic incident responders. Training is essential to familiarize the incident response personnel with the more automated methods of detecting, locating and verifying incidents. Cellular phone users must be educated in the use of the milepost/kilometerpost markers when reporting incidents to the 911 operators.

**For all expressway routes within the primary focus area:**

*Incident Reporting and Response*

- Milepost/kilometer-post markers, landmark signs, and route/direction designation signs
- "Call 911" signs for low-tech, low-cost incident detection system
- Educate cellular phone users on what information is necessary to report an incident; i.e. develop insert for cellular phone bills with the roadside marker and how to read it
- Existing MC 911 Center continues taking calls for expressway incidents, but in an increased capacity
- Appropriate police agency dispatched to verify/assess incidents, establish command post; field command will continue in the same manner with the 911 Center as the point of contact
- Develop relationship with the Emergency Citizens Band Stations group; provide construction and maintenance information on a weekly basis; ECBS should provide incident related information to the 911 Center

*Incident and Traffic Management*

- Develop retraining program for field commanders to understand the TOC functions and management capabilities; establish clear signing plans and response protocols for incident management
- Set up the temporary Traffic Operations Center which will be responsible for the coordination of construction and maintenance between the County, City, State and Thruway Authority agencies, coordination of traffic for special events management by utilizing portable, cellular-controlled variable message signs (VMSs) and permanent highway advisory radio (HAR) transmitters (This step must be implemented in order to further the traffic and incident management process)
- Begin to establish closed-circuit television cameras in high accident locations for verification of cellular phone calls to 911, via low speed equipment over the public telephone network or over wireless transmissions
    - Two locations along Keeler Expressway
    - I-490 at Troop-Howell Bridge
    - I-490 / I-590 can 0' worms

- Develop Expressway Service Patrols (ESP) with private sponsorship(s) on the routes with the highest number of incidents totaling 28 miles
  - Route 104 between Genesee River and Route 590
  - I-490 between Route 33 and I-590
  - I-390 between I-490 and I-590
- Develop early action initial Incident and Traffic Management system for the 5 miles of Route 104 and East Ridge Road between Route 590 and the Genesee River consisting of portable and fixed VMS, wireless CCTV cameras, RWIS, HAR system and roadway markers.
- Develop and prepare design packages for the ATMS for the route segments with the highest benefit :cost ratios amounting to a 30 mile system:
  - Route 104 and East Ridge Road between Route 390 and Route 590
  - I-490 between Route 33 and I-590
  - I-390 between I-490 and I-590

*Traveler Information*

- Implement portable, cellular-controlled VMSs to manage pre-planned incidents; i.e. roadway construction, special events, maintenance activities, etc. Also, provide motorist information along Keeler Expressway and East Ridge Road.
- Utilize a network of permanent HAR transmitters to cover the county to aid in the management of traffic during pre-planned incidents; i.e. construction, maintenance, special events and major incidents involving lane closures or entire roadway closures of long duration or that allow sufficient time to set up portable VMSs and record HAR broadcast messages
- Begin to advance to real-time management of traffic incidents with portable, cellular-controlled VMSs and permanent HAR transmitters

*Miscellaneous*

- Increase RWIS coverage of system sensors; partner with the telecommunications companies and/or cable television companies for communications into the temporary traffic operations center and also download the information to the various municipal dispatchers

Within the immediate study area in Monroe County:

| Number | Location | Description |
|---|---|---|
| 4-3-l | I-590/I-490/Route 590 | On each level of the interchange |
| 4-3-2 | I-390/I-590 | On the mainline and the ramps |
| 4-3-3 | I-490/Route 96 | On I-490 mainline |
| 4-3-4 | I-490/Inner Loop | On I-490 under the railroad |
| 4-3-6 | Route 104/Salt Road | On the Route 104 bridge |
| 4-3-7 | I-490/Inner Loop | On the Troup-Howell bridge |
| 4-3-8 | Route 104/Genesee River | On the Route 104 bridge |
| 4-4-3 | I-390/Airport | On I-390 mainline-areawide info |
| 4-4-4 | I-490/Union St | On I-490 mainline-areawide info |

Outside the immediate study area:

| Number | Location | Description |
|---|---|---|
| 4-1-2 | Route 33/Route 19 | Areawide info at the interchange |
| 4-8-2 | Route 104/Route 350 | Areawide info at the interchange |
| 4-4-1 | Ontario State Parkway/ Route 19 | Areawide info at the interchange |
| 4-4-2 | Ontario State Parkway/ Manitou Beach Road | Areawide info at the interchange |

Key: 4-4-l is Region 4 - Residency West - Location number
4-3-l is Region 4 - Residency East - Location number

(Note: There are several other locations within Region 4 but outside Monroe County)

- Develop standards for construction projects to include ITS elements; i.e. fiber optic conduit and pull boxes while the roadway/shoulders are excavated (This is a critical step to reducing the expense of developing a fiber optic network and a communications plant to support the ITS equipment)

- Develop private partnerships in communications infrastructure, technology testing, traveler information systems, Expressway Service Patrols, etc.

- Coordinate with the Monroe County Communications Master Plan

*Traffic Operations Center*

- Finalize site selection for a permanent TOC and possible joint TCC and begin design of the facility

- If the TOC and the TCC are not co-located; develop the direct connection links between the NYSDOT TOC and the MCDOT TCC

*Traffic Signal Control*

- Develop strategies for upgrading and expanding the MCDOT traffic signal system(s)/NYSDOT closed loop traffic signal system(s)
  - Begin design of system upgrade to allow for future integration with the NYSDOT TOC
  - Develop interim incident traffic signal timing plans
  - Develop remote access capabilities for off-hour monitoring of the system
  - Design and implement emergency vehicle traffic signal preemption system for routes between city fire stations and expressway entrance ramps
  - Upgrade the central communications units of the traffic signal controllers on the Monroe County signal system
  - Replace the existing traffic signal system central hardware and software
  - Replace the existing traffic signal system communications plant
  - Upgrade existing traffic signal field controllers on the Monroe County signal system

The estimated cost for the Traffic Signal System Upgrade described for the Near-Term is between $2 and $3 million. The estimated capital costs for the implementation described for the primary routes for the Near-Term is $2.2 million.

In Table VII-2, the benefit/cost ratio for the Near-Term phase includes the costs associated with a fully instrumented system for the Keeler Expressway. In Tables VII-3 and VII-4, the Near-Term phase of the implementation includes some costs for highway advisory radio transmitters, communications, roadway markers and other costs that are associated with the beginning of the fully instrumented ATMS. In addition to these costs, the costs associated with the Roadway/Weather Information System equipment, are also included in the Near-Term. The benefit/cost ratios for the RWIS can be calculated separately on the basis of an areawide system. The revised benefit/cost ratio for the Near-Term phase is calculated to be 2.62. This benefit/cost ratio includes the cost of the equipment associated with the Near-Term Keeler Expressway corridor between the Genesee River and Route 590 and takes into account the fact that the system is not fully instrumented by using 75 percent of the total benefit. The Near-Term expenditure includes four (4) variable message signs for the Keeler Expressway/Route 104 corridor, a highway advisory radio system to cover the entire ATMS area, four (4) CCTV cameras (two for the Keeler Expressway, one for the Troop-Howell Bridge and one for the Can 0' Worms), two (2) total stations which would be used for the entire Monroe County area, reference/milepost markers for 100 miles of expressway in the County and nine (9) RWIS sites throughout the County. The benefits associated with these costs are not easily quantifiable to accurately determine the benefit/cost ratios for the entire Near-Term expenditure. However, as mentioned in the Executive Summary, Traveler Information does account for large reductions in travel time, delay and emissions over a large geographic area. Therefore, it is safe to say that the benefit/cost ratio for the entire Near-Term implementation could be estimated to be greater than 3 : 1.

2. ***Short-Term, 2 to 5 years:***

*Incident Reporting and Response*

- Move and/or expand the Expressway Service Patrols to include a total of 25 additional miles:
    - Route 590 between I-490 and the northern terminus
    - I-390 south between I-590 and NYS Thruway
    - I-490 between I-590 and NYS Thruway
    - I-590 between I-490 and I-390
- Increase the usage of closed-circuit television cameras

*Incident and Traffic Management*

- Construct and Implement the ATMS for the route segments with the highest benefit :cost ratios amounting to a 30 mile system:
    - Route 104 and East Ridge Road between Route 390 and Route 590
    - I-490 between Route 33 and I-590
    - I-390 between I-490 and I-590

*Traveler Information*

- Develop fixed locations for variable message signs along each route and at major decision points
- Increase the route segments to be covered with VMSs, and wireless CCTV
- Begin implementation of traveler information kiosks at major traffic generators and major employment centers.

*Miscellaneous*

- Test option of wireless transmission of video images to the temporary TOC
- Begin to develop the regional fiber optic communications network and transition communications and control connections of field equipment from public telephone network and wireless onto the fiber optic line

*Traffic Operations Center*

- Develop the permanent TOC
- Establish the links between the RGRTA dispatch center and the NYSDOT TOC and the MCDOT TCC

The total capital cost for the Short-Term Implementation is $12.4 million, which includes over $6 million in capital cost for the fiber optic communication system. The additional cost to upgrade or expand the traffic signal system is estimated to be approximately $4.1 million.

***3. Medium-Term, 5 to 10 years:***

Increase the intensity and the coverage of the Intelligent Transportation Systems:

*Incident and Traffic Management*

- Begin design and construction of the ATMS for these routes with the next greatest benefit:cost ratios totaling an additional 35 miles:
  - Route 590 between I-490 and the northern terminus
  - I-390 between I-590 and NYS Thruway

- I-490 between I-590 and NYS Thruway
- I-590 between I-490 and I-390
- Route 3 1 between Inner Loop and Route 250
- Route 390 between Route 104 and I-490

*Traffic Operations Center*

- Begin to develop plans for the TOC expansion and increase the staffing to accommodate the increased expressway coverage

The total capital cost for the Medium-Term Implementation is $11.6 million, which includes over $6.9 million in capital cost for the fiber optic communications system. The additional cost to expand/upgrade the signal system along the arterial routes would be estimated at $8.2 million.

### 4. *Long-Term, 10 + years:*

*Incident and Traffic Management*

- Develop the ATMS expansion plans for the remaining 35 miles of expressway segments in the Greater Rochester Area

*Traffic Operations Center*

- Continue to expand the Coordinate / Managed Traffic signal system coverage for additional signals within the coverage area of the ATMS

The total cost for the Long-Term Implementation is $8.8 million. The additional cost to expand the traffic signal system to cover the remaining signalize routes within the study area is $5.4 million.

### 5. *Guide to Deployment of Intelligent Transportation System Equipment:*

***General***

This is intended to be a guide for locating Intelligent Transportation System equipment along roadways in the Greater Rochester area. The database of traffic and accident information should be used as a basis for locating nonrecurring and recurring congestion. This database should be used to define which routes and the limits of each route for deploying ITS.

Currently available and acceptable, State-of-the-Art technology should be employed whenever possible. However, life cycle cost comparison should be used to determine the most cost effective equipment to be used. The cost of training, maintenance and operation should be important criteria.

**RECURRING CONGESTION CRITERIA**

| FREEWAY/INTERSTATE | DIVIDED ARTERIAL | UNDIVIDED ARTERIAL |
|---|---|---|
| 15,000 ADT/LANE | 10,000 ADT/LANE | 7,500 ADT/LANE |
| LOS E/F | LOS E/F | LOS EIF |

**NONRECURRING CONGESTION CRITERIA**

| FREEWAY/INTERSTATE | DIVIDED ARTERIAL | UNDIVIDED ARTERIAL |
|---|---|---|
| 12,000 ADT/LANE | 8,000 ADT/LANE | 5,000 ADT/LANE |
| 7-8 ACCIDENTS/LANE MILE | 11-12 ACCIDENTS/LANE MILE | 14-15 ACCIDENTS/LANE MILE |
| LOS D, E/F | LOS D, E/F | LOS D, E/F |

Benefit: Cost ratios should be developed to determine the order in which systems and system components should be deployed and the intensity of equipment and systems.

Choices for traffic diversion routes should be prioritized as follows:

| | |
|---|---|
| First: | Limited Access Highway to Limited Access Highway |
| Second: | Major Arterial Roadway to Limited Access Highway |
| Third: | Limited Access Highway to Major Arterial Roadway |
| Fourth: | Major Arterial Roadway to Major Arterial Roadway |
| When and where appropriate: | Diversion to Mass Transportation |

The key to mitigating the impact of diverted traffic on any one roadway is to provide the information as wide spread as possible to the motorists. This allows the motorist to choose the diversion route well in advance of the incident. Providing information to the motorist about the extent of the queue developed by the incident may help motorists to stay on their route to reach their destination.

***Diversion Routes***

If the alternate Interstate or Limited Access Highway has not been instrumented, then manual means of monitoring the alternate route should be deployed until the alternate route has been instrumented. This can be accomplished through roaming service patrols and cellular call-in by motorists to the areawide 911 center or available Traffic Operations Center.

An analysis of the capacity of the available adjacent alternative roadways should be performed. A list of criteria which would eliminate a roadway from being an alternative route is as follows:

Substandard roadway alignment or geometrics
Lack of shoulders
Residential areas
Schools
Hospitals
Heavy pedestrian traffic
Active railroad crossings
Substantial change in speed limits
Circuitous routes
Roads which require resurfacing and/or reconstruction
No traffic signals to control or use to artificially increase capacity for diverted traffic.

***Variable Message Signs (VMSs):***

*On Interstates and other Limited Access Highways:*

VMSs should be placed prior to interchanges with Interstates and other Limited Access Highways for alternate route diversion. VMSs should be placed approximately 3/4 of a mile prior to the alternative route decision point; keeping in mind the sight distance necessary to read a message of three panels of three lines each at the prevailing speed of the roadway. Special attention should be given to vertical and horizontal curves.

*On Major Arterial Roadways; at least two (2) lanes per direction:*

VMSs should be placed prior to interchanges with Interstate and other Limited Access Highways as well as Major Arterial Roadways.

VMSs should be placed approximately one 1/2 mile prior to the decision point; keeping in mind the sight distance necessary to read a three-panel message at the prevailing speed of the facility. Special attention should be given to vertical and horizontal curves.

*On Minor Arterial Roadways; one (I) lane per direction:*

The option of smaller, less sophisticated and less expensive changeable message signs (CMSs) should be considered (i.e. rotating drum signs, blank-out signs, or electro-mechanical flip panel signs). These CMSs should be used due to their relative cost as compared to the number of motorists that will use the information on the CMS. The magnitude of the number of such locations that would be deployed and the size of the CMSs as compared to the full VMSs should also be a consideration. The use of these CMSs would be less obtrusive and would provide information to the motorist as to the conditions of the adjacent facility (i.e. either normal conditions ahead with no message; or roadway closed ahead using the appropriate message).

VMSs should avoid being located prior to interchanges with roadways that have little or no capacity to accept the diverted traffic

***Closed Circuit Television Cameras (CCTV):***

*On Interstates and other Limited Access Highways:*

CCTV cameras should be deployed along roadways that meet the criteria for high accident locations. CCTV cameras should be placed at such intervals as to cover the entire segment of roadway that meets this criteria.

For all other Interstate and Limited Access Highway segments, CCTV cameras should be considered at interchanges with other Interstate and Limited Access Highways, and interchanges with Major Arterial Roadways. More than one CCTV camera may be needed; each site is specific. These CCTV cameras would be used to verify the conditions of interchanges to diversion routes before, during and after a diversion plan. In many cases the capacity of the interchange is unable to accept the additional traffic volume, especially at peak traffic times. The CCTV images could be used to determine whether diversions should be used and/or continued or be discontinued.

*On Major Arterial Roadways; at least two (2) lanes per direction:*

CCTV cameras should be deployed along such roadways that meet the criteria for high accident locations. CCTV cameras should be placed at such intervals as to cover the entire segment of roadway that meets this criteria. Spacing would be dependent upon available technology and vertical and horizontal geometry.

For all other Major Arterial Roadway segments, CCTV cameras should be considered at interchanges with Interstate and Limited Access Highways, and interchanges with other Major Arterial Roadways. These CCTV cameras would be used to verify the condition of the diversion route interchanges before, during and after a diversion plan implementation. In many cases the capacity of the interchange is unable to accept the additional traffic volume, especially at peak traffic times. The CCTV camera images could be used to determine whether diversions should be used and/or continued or be discontinued.

*On Minor Arterial Roadways; one (1) lane per direction:*

CCTV cameras should be deployed along such roadways that meet the Integrated Transportation Management System Master Plan criteria for high accident locations. CCTV cameras should be placed at such intervals as to cover the entire segment of roadway that meets this criteria.

For all other Minor Arterial Roadway segments, CCTV cameras should be considered at interchanges with other Minor Arterial Roadways, Interstate and Limited Access Highways, and interchanges with Major Arterial Roadways. These CCTV cameras would be used to verify the condition of the diversion route interchanges during a diversion implementation. In many cases the capacity of the interchange is unable to accept the additional traffic volume, especially at peak traffic times. The CCTV camera images could be used to determine whether diversions should be used and/or continued or be discontinued.

In some cases, CCTV camera coverage would not provide the most benefit as compared to its cost due to the detection systems which will be deployed along the higher capacity roadways ***(See "Traffic Volume, Travel Speed and Traffic Density Detection Systems")***. These detection systems would provide information on speed, traffic volume and remaining capacity on the diversion routes. CCTV camera coverage would be an added expense that may not be justified. Benefit:cost analysis should be performed.

***Traffic Volume, Travel Speed and Traffic Density Detection Systems***

Detection equipment should be deployed along roadways that meet the criteria for high incident roadways. It also must be considered that detection equipment be deployed along segments of roadways that act as links between alternative route. These detection systems could provide valuable information with regard to travel speeds and traffic volumes to determine the usefulness of a link for diversion purposes.

*On Interstates and other Limited Access Highways:*

Detection Systems should be deployed on Interstates and other Limited Access Roadways that meet the high accident criteria from the Integrated Transportation Management System Master Plan and should be placed at intervals along the roadway that provide the most cost-effective use of such systems (i.e. 1/2 mile spacing or between interchanges). Whenever possible, detection equipment should be employed that is nonintrusive to the flow of traffic. This provides detection equipment that can be installed, operated and maintained with minimal disruption to traffic flow.

*On Major Arterial Roadways; at least two (2) lanes per direction:*

Detection Systems should be deployed on Major Arterial Roadways that meet the high accident criteria and should be placed at intervals along the roadway that provide the most cost-effective use of such systems (i.e. l/2 mile spacing or between interchanges). Whenever possible, detection equipment should be employed that is nonintrusive to the flow of traffic. This provides detection equipment that can be installed, operated and maintained with minimal disruption to traffic flow.

*On Minor Arterial Roadways; one (1) lane per direction:*

Detection Systems should be deployed on Minor Arterial Roadways that meet the high accident criteria from the Integrated Transportation Management System Master Plan and should be placed at intervals along the roadway that provide the most cost-effective use of such systems (i.e. l/2 mile spacing or between interchanges). Whenever possible, detection equipment should be employed that is nonintrusive to the flow of traffic. This provides detection equipment that can be installed, operated and maintained with minimal disruption to traffic flow.

***Coordinated Arterial Traffic Signal Systems***

The coordination of traffic signal control should be deployed along those signalized arterial roads that meet the criteria.

In some special cases, control of an isolated traffic signal would be necessary when that signalized intersection provides access between alternative routes.

Management of coordinated traffic signal systems should follow the criteria for high accident locations along arterial roadways. In such cases the deployment of CCTV should follow the ***"Closed Circuit Television Cameras (CCTV)"*** section of this guide. The deployment of VMSs should follow the criteria for ***"Variable Message Signs (VMSs)"*** in this guide. The deployment of detection equipment should follow the section on ***"Traffic Volume, Travel Speed and Traffic Density Detection Systems"***.

***Highway Advisory Radio transmission (HAR)***

It is recommended that a system of individual HAR transmitters be deployed to cover the entire area. The transmission ranges should be set and the transmitters should be located such that they do not overlap or interfere with one another. An areawide initiative should be deployed. This initiative should coordinate with the HAR along the New York State Thruway. Some degree of cooperation, coordination and shared use of the messages on HAR between the Thruway Authority and the State in the area should be developed based upon location, severity and impact of an incident on the adjacent agencies roadway.

### c. Benefits / Costs

Average annual daily traffic (AADT) volumes and the two year average ( 1991 and 1992) accident frequency data were provided by the New York State Department of Transportation. These data were summarized by roadway segment into tables for the primary expressway routes and the secondary arterial routes (see Appendix A). A typical roadway segment on the expressways is between interchanges and between intersections on the arterial routes. The peak hour traffic volumes were calculated by multiplying the AADT by a factor of 14 percent. The two year average accident frequency data were multiplied by a factor of seven (7) to arrive at the number of incidents and by a 10 percent factor to arrive at the number of peak hour incidents. These factors are nationally accepted statistics; for the ratio of incidents to accidents and for the peak hour incident totals. To calculate the benefits of implementing the advanced transportation management system (ATMS), an amount of time saved per vehicle per incident was determined. In order to calculate the reduction of vehicle-hours of delay for an incident, eight (8) minutes of time saved was utilized. This is a nationally accepted statistic for reduction in delay with transportation management equipment installed. The amount of traffic that passes the total number of accidents during the peak hour multiplied by the eight (8) minutes of savings is the total amount of vehicle hours of delay saved on that segment of roadway.

Figure VII-l shows the segmentation of the expressways. The segmentation is based upon logically manageable routes. These segments eventually become one cohesive and comprehensive system to be managed.

To calculate the cost of the segments, the equipment (VMS units, HAR transmitters and CCTV cameras) was placed on the map of the area (see Figures VII-2, VII-3, VII-4). The total capital costs were summarized for each segment. The annualized capital cost of the equipment was calculated using a factor of 0.1295 which is based upon a 5 percent annual rate of interest over a 10 year period. Ten years is the expected life of much of this equipment. The total annualized capital cost was divided into the total annualized benefit for each segment. This is the annual benefit cost ratio for each segment of roadway.

Tables VII-2, VII-3, VII-4, VII-5, VII-6 and VII-7 included at the end of this chapter, summarize the annualized benefit cost ratios, total capital costs and the annualized costs for the expressways and arterial routes in the Greater Rochester Area. Table VII-2 includes the phases of the implementation based on the relative benefit cost ratios as well as continuity of phasing each segment. The recommendations for the expressways are listed in the Strategic Implementation/Deployment Plan. The Near-Term Implementation Plan includes variable message signs and closed circuit cameras, as well as roadway reference markers, “911 Call-In” signs, two total stations for accident investigation by police and allocation for related equipment for a temporary traffic operations center. The Short-Term Implementation Plan of the Strategic Implementation/Deployment Plan describes the development of the first four (4) expressway segments with the highest benefit cost ratios. The approximate total Capital expenditure for the equipment for the Short-Term phase listed in Table VII-3 is approximately $12.4 million. The second phase or the Medium-Term, 5 to 10 year plan is to complete the next four (4) expressway segments with the next highest benefit cost ratios. The total Capital cost for the equipment for the Medium-Term described in Table VII-3 is approximately $11.6 million. The remaining expressway segments in the study area could be completed at a later date at a total Capital cost of $8.8 million.

The secondary arterial routes are instrumented in a slightly different manor. Changeable message signs (CMS) are recommended over variable message signs (VMS). CMS are less obtrusive than VMS. VMS are generally brighter and larger than CMS. CMS are usually limited in the amount of information that can be displayed. At key interchanges of high volume arterial routes, it may be warranted to install VMS to provide more information to the motorist. During the design stages of this project, a benefit cost comparison would be needed, based upon the number of vehicles that pass the particular sign location and the amount of information that is needed to transmit to the motoring public. For example, a relatively low volume arterial route that feeds the expressway would only need a CMS to inform travelers on which route to continue. But a high volume arterial route that feeds the expressway may need a full VMS to display the necessary information.

The cost calculations tables, for the expressways and arterial routes (Tables VII-3 and VII-6), list the equipment that is proposed to be implemented along each roadway segment. The Intelligent Transportation System (ITS) equipment is tabulated along with their total capital cost. The annualized costs are used to calculate the annual benefit cost ratios. It was determined that Service Patrols would be pursued as a partnership with the private sector. The private sponsor would cover the majority of the cost of the patrol.

TABLE VII-1

Potential Variable Message Sign Locations

| Traveling | On | Prior to | Type | In/Outbound | Diversion from | To |
|---|---|---|---|---|---|---|
| SB | 390 | 104 | Perimeter | Inbound | Freeway | Arterial |
| EB | 104 | 390 | Perimeter | Inbound | Arterial | Freeway |
| EB | 104 | EB Service Rd | Internal | Circumferential | Freeway | Service Rd |
| EB | 104 | 590 | Internal | Circumferential | Freeway | Freeway |
| WB | 104 | WB Service Rd | Internal | Circumferential | Freeway | Service Rd |
| SB | 590 | 104 | Perimeter | Inbound | Freeway | Freeway |
| EB | 531 | 490 | Perimeter | Inbound | Freeway | Freeway |
| EB | 490 | 204/Airport Exp | Perimeter | Inbound | Freeway | Arterial |
| WB | 490 | Mt Read Blvd | Internal | Outbound | Freeway | Arterial/Freeway |
| EB | 490 | Mt Read Blvd | Internal | Inbound | Freeway | Arterial |
| WB | 490 | 531 | Internal | Outbound | Freeway | Freeway |
| EB | 490 | Inner Loop | Internal | Inbound | Freeway | Freeway |
| WB | 490 | Inner Loop | Internal | Inbound | Freeway | Freeway |
| SB | South Ave | Broad St | Internal | Outbound | Arterial | Arterial |
| SB | Chestnut | Woodbury | Internal | Outbound | Arterial | Arterial |
| EB | Brooks Ave | 390 | Perimeter | Circumferential | Arterial | Freeway |
| NB | 390 | 390/590 | Perimeter | Inbound | Freeway | Freeway |
| SB | 390 | W Henrietta Rd | Internal | Outbound | Freeway | Arterial |
| NB | 390 | Scottsville/383 | Internal | Circumferential | Freeway | Arterial |
| NB | 390 | Chili Ave/33A | Internal | Circumferential | Freeway | Arterial |
| NB | 31 | 590 | Perimeter | Inbound | Arterial | Freeway |
| NB | 590 | Empire/404 | Internal | Outbound | Freeway | Arterial |
| SB | 590 | Browncroft Blvd | Internal | Circumferential | Freeway | Arterial |
| NB | 390 | E Henrietta Rd | Perimeter | Inbound | Freeway | Arterial |
| NB | 490 | Linden/441 | Perimeter | Inbound | Freeway | Arterial |
| NB | 490 | 31F | Perimeter | Inbound | Freeway | Arterial |
| NB | 490 | 31 | Perimeter | Inbound | Freeway | Arterial |
| WB | 490 | Monroe/31 | Internal | Inbound | Freeway | Arterial |
| EB | 490 | Monroe/31 | Internal | Outbound | Freeway | Arterial |
| NB | 590 | 31 | Internal | Circumferential | Freeway | Arterial |
| SB | 590 | Monroe/31 | Internal | Circumferential | Freeway | Arterial |
| SB | 590 | 390 | Internal | Circumferential | Freeway | Freeway |
| WB | 104 | Bay Road | Perimeter | Inbound | Freeway | Arterial |
| SB | 390 | Ridgeway Ave | Internal | Inbound | Freeway | Local |
| EB | 490 | Buffalo Rd/33 | Perimeter | Inbound | Freeway | Arterial |

## Table VII-2 Annual Benefit/Cost Calculations
## Primary Routes

| Fully Instrumented Phase | Seoment Name | Fully Instrumented Annual Benefit: Cost | Less Than Fully Instru Annual Benefit: Cost | Fully Instrumented Annual Benefit (B) | Less Than Fully Instru Annual Benefit (B) | Length(mi) | Fully Instrumented Annual Benefit/Mile | Less Than Fully Instru Annual Benefit/Mile |
|---|---|---|---|---|---|---|---|---|
| Medium Term | Route 31 - Inner Loop to Rte 250 | 2.14 | 13.47 | $584,300 | $292,150 | 7.00 | $83,471 | $41,736 |
| Long Term | Route 104 - Rte 261 to Rte 390 | 0.92 | 51.26 | $1233,807 | $61,903 | 3.73 | $33,192 | $16,596 |
| Short Term | Route 104 - Rte 390 to Genesee R | 5.16 | 8.07 | $957,164 | $478,582 | 3.29 | $290.931 | $145,486 |
| Near Term(4) | Route 104 - Genesee R to Rte 590 | 1.07 | 1.25 | $334,914 | $167,457 | 4.83 | $69,340 | $34,670 |
| Long Term | Route 104 - Rte 590 to County Line | 0.37 | 10.98 | $116,373 | $58,186 | 8.37 | $13,904 | $6,952 |
| Long Term | Route 390 - Rte 104 to Ontario Pkwy | 0.29 | 16.71 | $43,595 | $21,798 | 4.03 | $10,818 | $5,409 |
| Medium Term | Route 390 - Rte 104 to f-490 | 2.26 | 7.25 | $294,720 | $147,360 | 2.80 | $105,257 | $52,629 |
| Medium Term | I-390 - I-590 to Thruway | 1.57 | 5.38 | $219,770 | $109,885 | 3.08 | $71,354 | $35,677 |
| Short Term | I-390 - I-490 to t-590 | 3.20 | 6.85 | $1.349,992 | $674,996 | 8.43 | $160,141 | $80,071 |
| Long Term | I-490 -Thruway to Airport Expwy | 0.11 | 3.99 | $62,741 | $31,371 | 16.29 | $3,852 | $1,926 |
| Short Term | I-490 - Rte 33 to Rte 441 | 3.02 | 4.63 | $1.976.229 | $988,115 | 11.48 | $172,145 | $86,073 |
| Short Term | Inner Loop | 0.47 | 0.53 | $88,727 | $44.363 | 2.33 | $38,080 | $19,040 |
| Short Term | Total I-490 & Inner Loop | 2.49 | 3.63 | $2.064,956 | $1,032.478 | 13.81 | $149,526 | $74,763 |
| Medium Term | I-490 - I-590 to Thruway | 1.39 | 5.02 | $578,039 | $289,019 | 9.68 | $59,715 | $29,857 |
| Long Term | Route 531 - Rte 36 to I-490 | 0.30 | 17.42 | $24,030 | $12,015 | 2.13 | $11.282 | $5,641 |
| Medium Term | Route 590 - I-490 to north terminus | 1.74 | 6.35 | $520,964 | $260.482 | 6.74 | $77,294 | $38,647 |
| Medium Term | I-590 - I-390 to I-490 | 0.83 | 1.83 | $219.894 | $109.947 | 5.31 | $41,411 | $20,706 |
| | TOTAL | 1.65 | 4.54 | $7.495,259 | $3,747,629 | 99.52 | $75,314 | $37,657 |

**. Detection Systems, CCTV and Fiber Optic Communlcatbns NOT Included in the "Less Than Fully Instrumented" Calculations
## Service Patrols NOT Included In Total Cost to NYSDOT
"Less Than Fully Instrumented' Benefits equal 50% of "Fully Instrumented" Benefits
Annualization Factor for 10 yrs 0.1295 (5% Interest)
Each SP vehicle patrols 10 miles
Delay saved /incident assumed 0 minutes

# Table VII-3 Total Capital Costs
## Primary Routes

TOTAL CAPITAL COSTS

| Fully Instrumented Phase | Segment Name | Fully Instrumented CapitalCosts | LessThan Fully Inslru CapitalCosts | (1) Roadway Markers | ## Service Patrols | (1) HAR Transmitter | (2) VMS fixed | VMS fixed | Weather Detection | Traffic" Detection | (3) CCTV" | CCTV'" | Fiber Optic ** Communical |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Medium Term | Route31-InnerLoop to Rte 250 | $1,927.500 | $167,590 | $17,500 | | | $150,000 | 1 | | $240,000 | $120,000 | 4 | $1.400.000 |
| Long Term | Route 104 Rte 261 t0 Rte 390 | $935,325 | $9,325 | $9,325 | | | $0 | 0 | | $120,000 | $60,000 | 2 | $746,060 |
| Short Term | Route104-Rte 390 to Genesee R | $1,476,225 | $458,225 | $8.225 | | | $450,000 | 3 | | $240,000 | $120,000 | 4 | $658,000 |
| NearTerm(4) | Route l04-Genesee R to Rte 590 | $2,378,075 | $1.032.075 | $12,075 | $84,525 | **$200,000** | $800,000 | 4 | $20,000 | $240,000 | $140,000 | 4 | $966,000 |
| Long Term | Route 104- Rte 590 to County Line | $2,434.925 | $40,925 | $20,925 | $146.475 | | $0 | 0 | $20,000 | $480.000 | $240,000 | 8 | $1,674,000 |
| Long Term | Route 390 · Rte 104 to Ontario Pkwy | $1,176,075 | $10,075 | $10,075 | $70,525 | | $0 | 0 | | $240,000 | $120,000 | 4 | $606,000 |
| Medium Term | Route 390 - Rte 104 to I-490 | $1,077.000 | $157,000 | $7,000 | $49.000 | | $150,000 | 1 | | $240,000 | $120,000 | 4 | $560,000 |
| Medium Term | I-390- I-590 to Thruway | $1,133,700 | $157,700 | $7,700 | $53,900 | | $150,000 | 1 | | $240,000 | $120,000 | 4 | $616,000 |
| Short Term | I-390 · I-490 to I-590 | $3.347,075 | $761,075 | $21,075 | $147,525 | **$100,000** | $600,000 | 4 | $40,000 | $600,000 | $300,000 | 10 | $1,686,000 |
| Long Term | I-490-Thruway to Airport Expwy | $3,768,725 | $60,725 | $40,725 | $285,075 | | $0 | 0 | $20,000 | $300.000 | $150,000 | 5 | $3,258,000 |
| Short Term | I-490 · Rte 33 to Rte 441 | $5.204,700 | $1,648,700 | $28,700 | $200,900 | $100,000 | $1500,000 | 10 | $20,000 | $840,000 | $420,000 | 14 | $2.296.000 |
| Short Term | Inner Loop | $1,741,825 | $645,825 | $5,825 | $40,775 | | $600,000 | 4 | $40,000 | $420,000 | $210,000 | 7 | $466,000 |
| Short Term | Total I-490 & Inner Loop | | $2,194,525 | $34,525 | $241,675 | | $2,100,000 | 14 | $60,000 | $1.260,000 | $630,000 | 21 | $2,762,000 |
| Medium Term | I-490- I-590 to Thruway | $3.100.200 | $444,200 | $24,200 | $169,400 | $100,000 | $300,000 | 2 | $20,000 | $480,000 | $240,000 | 8 | $1,936,000 |
| Long Term | Route 531 · Rte 36 to I-490 | $611,325 | $5,325 | $5,325 | $37,275 | | $0 | 0 | | $120.000 | $60,000 | 2 | $426,000 |
| Medium Term | Route 590- I-490 to north terminus | $2,384,850 | $316,850 | $16,850 | $117,950 | | $300,000 | 2 | | $480,000 | $240,000 | 8 | $1,348,000 |
| Medium Term | I-590 -I-390 to I-490 | $2,155,275 | $463,275 | $13.275 | $92,925 | | $450,000 | 3 | | $420,000 | $210,000 | 7 | $1,062,000 |
| | TOTAL | $34,852,800 | $6.378.800 | $248,800 | $1,496,250 | $500,000 | $5,450,000 | 35 | $180,000 | $5.700,000 | $2,870,000 | 95 | $19,904,000 |
| | Unit Capital Costs | | | $2.500 | $175,000 | $100,000 | $150,000 | | 520,000 | $15,000 | $30,000 | | $200,000 |
| | Units | | | per mile | per vehicle | pertransmit | per sign | | per station | per station | per camera | | per mile |

** · Detection Systems, GCTV and Fiber Optic Communications NOT Included in the "Less Than Fully Instrumented" Calculations
## · Service Patrols NOT Included In Total Cost to NYSDOT
"Less Than Fully Instrumented" Benefits equal 50% of "Fully Instrumented" Benefits
Annualization Factor for 10 yrs 0.1295 (5% Interest)
Each SP vehicle patrols 10 miles
Delay saved/ incident assumed 8 minutes
(1). Near Term Includes HAR, Reference Markers, Total Stations and Temporary TOC Equipment
(2) Near Term VMS Also Includes 4 Portable VMS
(3) Near Term CCTV Includes Cost of Wireless Communications
(4) Near Term E/C Ratio Based Upon 75% Of Benefits And Cost Includes Only Equipment On Keeler Exp

# Table VII-4 Annualized Capital Costs
## Primary Routes

| Fully Instrumented Phase | Segment Name | ** Fully Instrumented Annual costs (C) | Less Than Fully Instrum Annual costs (C) | (1) Roadway Markers | ## service Patrols | (1) HAR Transmitter | (2) VMS fixed | VMS fixed | Weather Detection | Traffic ** Detection | (3) CCTV * | CCTV ** | Fiber Optic ** Communication |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | <- - - - - - - - - - - - - A N N U A L I Z E D | | C A P I T A L | C O S T S | - - - - - - - - - - - - - - - - | | - - - - - - - - - - - - - - - - -> | | | | | |
| Medium Term | Route 31 - Inner Loop to Rte 250 | $272.921 | $21,691 | $2,266 | | | $19,425 | 1 | | $54,390 | $15,540 | 4 | $181,300 |
| Long Term | Route 104 - Rte 261 to Rte 390 | $134,567 | $1,208 | $1 208 | | | $0 | 0 | | $28,982 | $7,770 | 2 | $96,607 |
| Short Term | *Route 104. Rte 390 to Genesee R* | $185,654 | $59,340 | $1,065 | | | $56,275 | 3 | | $25,563 | $15,540 | 4 | $85.211 |
| Near Temt(4) | Route 104 - Genesee R to Rte 590 | $314,410 | $133,654 | $1,564 | $10,946 | $25,900 | $103,600 | 4 | $2,590 | $37,529 | $18,130 | 4 | $125,097 |
| Lang Term | Route 104 - Rte 590 to County Line | $318.198 | $5,300 | $2,710 | $18,969 | | $0 | 0 | $2,590 | $65,035 | $31,080 | 8 | $216,783 |
| Long Term | Route 390 - Rte 104 to Ontario Pkwy | $152,535 | $1,305 | $1,305 | $9,133 | | $0 | 0 | | $31,313 | $15,540 | 4 | $104,377 |
| Medium Term | Route 396 - Rte 104 to I-490 | $130,148 | $20,332 | $907 | $6,346 | | $19,425 | 1 | | $21,756 | $15,540 | 4 | $72,520 |
| Medium Term | I-390 - I-590 to Thruway | $139,666 | $20,422 | $997 | $6,980 | | $19,425 | 1 | | $23,932 | $15,540 | 4 | $79.772 |
| Short Term | I-390 - I-490 to I-590 | $421,247 | $98,559 | $2,729 | $19,104 | $12,950 | $77,700 | 4 | $5.180 | $65,501 | $38,850 | 10 | $218.337 |
| Long Term | I-490 -Thruway to Airport Expwy | $575,773 | $7.864 | $5,274 | $36,917 | | $0 | 0 | $2,590 | $126,573 | $19,425 | 5 | $421,911 |
| Short Term | I-490 - Rte 33 to Rte 441 | $654.428 | $213.507 | $3,717 | $26,017 | $12,950 | $194,250 | 10 | $2,590 | $89,200 | $54,390 | 14 | $297,332 |
| Short Term | Inner Loop | $189,280 | $83.634 | $754 | $5,280 | | $77,700 | 4 | $5,180 | $18.104 | $27,195 | 7 | $60,347 |
| Short Term | Total I-490 & Inner Loop | $830,759 | $264,191 | $4,471 | $31,297 | | $271,950 | 14 | $7.770 | $107,304 | $81.585 | 21 | $357,679 |
| Medium Term | I-490 - I-590 to Thruway | $414,530 | $57,524 | $3,134 | $21,937 | $12,950 | $38,850 | 2 | $2,590 | $75,214 | $31.080 | 8 | $250,712 |
| Long Term | Route 531 - Rte 36 to I-490 | $80,177 | $690 | $690 | $4.827 | | $0 | 0 | | $16.550 | $7,770 | 2 | $55,167 |
| Medium Term | Route 590 - I-490 to north terminus | $299.048 | $41,032 | $2,182 | $15,275 | | $38,850 | 2 | | $52,370 | $31.080 | B | $174,566 |
| Medium Term | I-590 _ t-390 to I-490 | $265,977 | $59,994 | $1,719 | $12,034 | | $58,275 | 3 | | $41,259 | $27,195 | 7 | $137,529 |
| | TOTAL | $4,548,558 | $826.055 | $32,229 | $193,764 | $64,750 | $705,775 | 35 | $23,310 | $773,270 | $371,665 | 95 | $2,577,568 |
| | Annualized Unit Costs | | | $324 | $22,663 | $12,950 | $19,425 | | $2,590 | $1,943 | $3,885 | | $25.900 |
| | Unrts | | | per mile | per vehicle | per transmit | per sign | | per station | per station | per camera | | per mile |
| | Unit Capital Costs | | | $2,500 | $175,000 | $100,000 | $150,000 | | $20,000 | $15,000 | $30,000 | | $200,000 |

**. Dection Systems, CCTV and Fiber Optic Communications NOT included In the "Less Than Fully Instrumented" Calculations
##_ Service Patrols NOT Included In Total Cost to NYSDOT
'Less Than Fully Instrumented" Benefits equal 50% of "Fully Instrumented" Benefits
Annualization Factor for 10 yrs 0.1295 (5% Interest)
Each SP vehicle patrols 10 miles
Delay saved / Incident assumed 8 minutes
(1) . Near Term Includes HAR. Reference Markers, Total Statlons and Temporary TOC Equipment
(2) - Near Term VMS Also Includes 4 Portable VMS
(3) - Near Term CCTV Includes Cost of Wireless Communlcatlons
(4) - Near Term B/C Ratio 'Based Upon 75% Of Benefits And Cost Includes Only Equipment On Keeler Exp

# Table VII-5 Annual Benefit/Cost Calculations
## Secondary Routes

| Phase | Segment Name | * Fully Instrumented Benefit:Cost | Less Than Fully Instru Benefit:Cost | Fully Instrumented Annual Benefit (B) | Less Than Fully Instru Annual Benefit (B) | Length(ml) | Fully Instrumanted Annual Benefit/Mile | Less Than Fully Instru Annual Benefit/Mile |
|---|---|---|---|---|---|---|---|---|
| Short Term | West Henrietta Rd - Rte 252 to Byron St | 4.10 | 5.38 | $440.885 | $220.442 | 4.63 | $95.223 | $47,612 |
| Medium Term | West Henrietta Rd. Rte 253 to Ftte 252 | 1.30 | 1.74 | $120,779 | $60,390 | 3.60 | $26,066 | $13,043 |
| Short Term | E Henrietta Rd. Jefferson to Mt Hope | 9.77 | 11.20 | $646,235 | $324,117 | 2.64 | $245,544 | $122,772 |
| Medium Term | E Henrietta Rd -Town Line Ftd to Jefferson | 0.85 | 1.17 | $102,111 | $51,056 | 5.10 | $38.679 | $19,339 |
| Medium Term | Dewey Ave - City Line to Lyell Ave | 0.90 | 1.30 | $75.989 | $37,994 | 3.76 | $20,210 | $10.105 |
| Long Term | Latta/Dewey - Rte 390 to City Line | 2.47 | 3.57 | $210,266 | $105,133 | 3.80 | $55,922 | $27,961 |
| Short Term | Lyell - 390 to Chestnut | 2.66 | 3.48 | $281.319 | $140,659 | 4.54 | $61,994 | $30.982 |
| Long Term | Spencerport. Gillett to 390 | 10.25 | 13.53 | $1.147.975 | $573.987 | 4.87 | $252,856 | $126,429 |
| Medlum Term | Monroe Ave(31). Chestnut to Edgewood | 2.46 | 7.91 | $147,576 | $73.766 | 3.41 | $43.277 | $21,639 |
| Medium Ten | Fairport(31 F) _ East Ave to Jefferson Ave | 1.25 | 1.30 | $120.760 | $60.390 | 3.36 | $35,734 | $17,667 |
| Short Term | Buffalo Rd(33) - I-490 to Broad St | 1.72 | 2.61 | $203,019 | $101.510 | 5.36 | $37.677 | $16,936 |
| Long Term | Buffalo Rd(33). Rte 259 to I-496 | 1.65 | 2.42 | $171.761 | $65.861 | 4.80 | $32.045 | $16,022 |
| Short Term | Chill Ave(33A)- I-390 to West Ave(33) | 1.04 | 0.96 | $60.094 | $30.047 | 1.64 | $32.660 | $16,330 |
| Long Term | Chill Ave(33A)- Rte 259 to I-390 | 2.24 | 3.02 | $391.444 | $195,722 | 7.50 | $212,741 | $106,371 |
| Medlum Term | Clover St(65) - Rte 252 to Rte 31 | 1.07 | 1.36 | $47,974 | $23,967 | 1.84 | $26.073 | $13,036 |
| Medium Term | Jefferson Rd(96). Thruway to Main St | 0.44 | 0.63 | $73,556 | $36,776 | 7.50 | $9.807 | 34.904 |
| Short Term | East Ave(96) - I-490/590 to East Main St | 0.66 | 0.93 | $47,199 | $23,599 | 3.11 | $15,176 | $7,568 |
| Medium Term | East Ave(96) - Jefferson Rd to I-490/590 | 2.66 | 3.91 | $261,962 | $130,991 | 4.47 | $64.236 | $42.119 |
| Medlum Term | Route 153 - Rte 31 F to Rte 96 | 1.05 | 1 02 | $41.195 | $20,598 | 1.21 | $34,046 | $17,023 |
| Medium Term | Route 250 - Rte 96 to Rte 31F | 0.51 | 0.65 | $46,236 | $24.116 | 3.95 | $12.212 | $6.106 |
| Medium Term | Jefferson (252) - W Henrietta to Rte 96 | 3.21 | 4.20 | $514,539 | $257,269 | 6.91 | $74,463 | $37,231 |
| Long Term | Empire(404). Rte 590 to Wayne County | 1.21 | 1.60 | $266.206 | $134,104 | 10.16 | $26,396 | $13,199 |
| Near Term | East Ridge Rd -St Paul to Bay Shore | 1.32 | 1.91 | $113.727 | $56,864 | 3.86 | $29.463 | $14,732 |
| | TOTAL | 2.34 | 3.17 | $5,536,847 | $2.769,424 | 102.24 | $54.175 | $27,067 |

* * CCTV NOT included in the 'Less Than Fully Instrumented calculations

Annualization Factor-10 yrs 0 1295 (5% Interest)

On arterials CCTV *very 2 miles average

Delay saved per incident – 5 minutes

"Less Than Fully Instrumented" Benefits= 50% of Fully Instrumented Benefits

# Table VII-6 Total Capital Costs
## Secondary Routes

<--------------------TOTAL CAPITAL COSTS------------------------------

| Phase | Segment Name | * Fully Instrumented Capital:Costs | Less Than Fullv Instu Capital:costs | Cellular 911 Signs | Slgnal System Upgrade | CMS fixed | CMS fixed | Weather Detection | Traffic Detection | CCTV * | CCTV * | Communication Fiber Upgrade |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Short Term | West Henrietta Rd - Rte 252 to Byron St | $629.390 | $316.390 | $2.778 | $97.862 | $100,000 | 2 | | $115,750 | $50,000 | 2 | $463,000 |
| Medium Term | West Henrietta Rd - Rte 253 to Rte 252 | $676,252 | $268,252 | $2.160 | $76.092 | $100.090 | 2 | | $90.000 | $50.009 | 2 | $360,000 |
| Short Term | E Henrietta Rd _ Jefferson to Mt Hope | $512.364 | $223,384 | $1.584 | $55.800 | $100,000 | 2 | | $66,000 | $25,000 | 1 | $264,000 |
| Medium Ten | E Henrietta Rd -Town Line Rd to Jefferson | $923.356 | $338.356 | $3.060 | $107,796 | $100,000 | 2 | | $127,500 | $75,000 | 3 | $510,000 |
| Medium Term | Dewey Ave- City Line to Lyell Ave | $651,729 | $225,729 | $2,256 | $79.473 | $50,000 | | | $94,000 | $50,000 | 2 | $376,000 |
| Long Term | Lana/Dewey _ Rte 390 to City Une | $657.599 | $227,599 | $2,280 | $80.319 | $50,000 | | | $95.000 | $50,000 | 2 | $380,000 |
| Short Term | Lyell - 399 to Chestnut | $616,184 | $312.184 | $2.724 | $95,960 | $100.000 | 2 | | $113.500 | $50,000 | 2 | $454,000 |
| Long Term | Spencerport. Gillett to 390 | $864,607 | $327.607 | $2.922 | $102,935 | $100,000 | 2 | | $121,750 | $50,000 | 2 | $487,000 |
| Medium Ten | Monroe Ave(31) - Chestnut to Edgewood | $560.372 | $159.372 | $2.046 | $72.076 | $0 | 0 | | $85.250 | $50,000 | 2 | $341,000 |
| Medium Term | Fairport(31) F) - East Ave to Jefferson Ave | $746,970 | $357.970 | $2.028 | $71.442 | $200,000 | 4 | | $64.500 | $50.000 | 2 | $336.000 |
| Short Term | Buffalo Rd(33) - I-490 to Broad St | $911.506 | $300,506 | $3,216 | $113.292 | $50,000 | | | $$134,000 | $75.000 | 3 | $536.000 |
| Long Term | Buffalo Rd(33) - Rte 259 to I-490 | $604.335 | $274,335 | $2.680 | $101,465 | $50,000 | | | $120.000 | $50,000 | 2 | $480.000 |
| Short Term | Chili Ave(33A) . I-390 to West Ave(33) | $444,995 | $235,995 | $1.104 | 00000 | $150,000 | | | $46.000 | $25,000 | 1 | $164.000 |
| Long Term | Chili Ave(33A). Rle 259 to I-390 | $1.350.524 | $500.524 | $4.500 | $156,524 | $150,000 | 3 | | $167.500 | $100,000 | 4 | $750,000 |
| Medium Term | Clover St(65) . Rte 252 to Rte 31 | $344,995 | $135.995 | $1,104 | $36.691 | $50,000 | | | $46.000 | $25,000 | 1 | $184,000 |
| Medium Term | Jefferson Rd(96). Thruway to Main St | $1.300,524 | $460,524 | $4,500 | $156,524 | $100,000 | 2 | | $167.500 | $100,000 | 4 | $750.000 |
| Short Term | East Ave(96) - I-490/590 to East Main St | $566,351 | $195,351 | $1.866 | $65,735 | $50.000 | | | $77.750 | $50,000 | 2 | $311,000 |
| Medium Term | East Ave(96). Jefferson Rd to I-490/590 | $766.912 | $256.912 | $2.662 | $94.460 | $50,000 | | | $111,750 | $50,000 | 2 | $447,000 |
| Medium Term | Route 153 . Rte 31 F to Rte 96 | $302,551 | $156.551 | $726 | $25.575 | $100,000 | 2 | | $30,250 | $25.000 | 1 | $121,000 |
| Medium Term | Route 250 - Rte 96 to Rte 31 F | $729,609 | $284.609 | $2,370 | $83.469 | $100.000 | 2 | | $96.750 | $50,000 | 2 | $395,000 |
| Medium Ten | Jefferson (252) . W Henrietta to Rte 96 | $1,236,950 | $472,950 | $4.146 | $146,054 | $150,000 | 3 | | $172,750 | $75,000 | 3 | $691,000 |
| Long Term | Emplre(404) - Rte 590 to Wayne County | $1.715.643 | $574,643 | $6,096 | $214,747 | $100.000 | 2 | | $254,000 | $125,000 | 5 | $1,016.000 |
| Near Term | East Ridge Rd -St Paul to Bay Shore | $666,403 | $230,403 | $2,316 | $61,507 | $50,000 | | | $96.500 | $50,000 | 2 | $366,000 |
| | TOTAL | $16,352.344 | $6.828.344 | $61,344 | $2.161.000 | $2.050.000 | 41 | | $2.556.000 | $1.300.000 | 52 | $10,224,000 |
| | Total Capital Costs | | | $600 | $2,161,000 | $50.000 | | $20.000 | $25,000 | $25,000 | | $100,000 |
| | Units | | | per mile | per mile | per sign | | per station | per station | per camera | | per mite |

** CCTV NOT included in the 'Less Than Fully Instrumented' calculations

| | | |
|---|---|---|
| Annuallzatlon Factor -10 yrs | 0 1295 | (5% Interesf) |
| On arterials. CCTVevery | 2 | miles |
| Delay saved per incident = | 5 | minutes |
| "Less Than Fully Instrumented" Benefits= | | 50% |

## Table VII-7 Annualized Capital Costs
## Secondary Routes

| Phase | Segment Name | * Fully Instrumented Annual costs (C) | Less Than Fully Instru Annual costs (C] | Cellular 911 Signs | Signal System Upgrade | CMS FIXED | CMS fixed | Weather Detection | Traffic Detectlon | CCTV • | CCTV I | Communication Fiber Upgrade |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | <- - - - - - - - - - - - - - - - - ANNUALIZED CAPITAL COSTS - - - - - - - - - - - - - - - - - - - - - - - - -> | | | | | | | | | | |
| Short Term | West Henrietta Rd _ Rte 252 to Byron St | $107,406 | $40,973 | $360 | $12.673 | $12.950 | 2 | | $14.990 | $6.475 | 2 | $59.959 |
| Medium Term | West Henrietta Rd. Rte 253 to Rte 252 | $87,834 | $34739 | $260 | $9,854 | $12,950 | 2 | | $11,655 | $6,475 | 2 | $46.620 |
| Short Term | E Henrietta Rd - Jefferson to Mt Hope | $66,354 | $26,926 | $205 | $7,226 | $12,950 | 2 | | $8,547 | $3,236 | 1 | $34.168 |
| Medium Term | E Henrietta Rd -Town Line Rd to Jefferson | $119,575 | $43,617 | $396 | $13,960 | $12.950 | 2 | | $16.511 | $9.713 | 3 | $66,045 |
| Medium Term | Dewey Ave. City Line to Lyell Ave | $64,399 | $29,232 | $292 | $10.292 | $6,475 | 1 | | $12.173 | $6,475 | 2 | $46,692 |
| Long Term | Lana/Dewey - Rte 390 to City Line | $65.159 | $29,474 | $295 | $10.401 | $6,475 | 1 | | $12.303 | $6,475 | 2 | $49.210 |
| Short Term | Lyell- 390 to Chestnut | $105.696 | $40.426 | $353 | $12,427 | $12.950 | 2 | | $14,696 | $6,475 | 2 | $58.793 |
| Long Term | Spencerport . Gillett to 390 | $111,967 | $42,425 | $376 | $13.330 | $12.950 | 2 | | $15.767 | $6,475 | 2 | $63.067 |
| Medium Term | Monroe Ave(31). Chestnut to Edgewood | $59,966 | $9,334 | $0 | $9,334 | $0 | 0 | | $0 | $6.475 | 2 | $44,160 |
| Medium Term | Fairport(31 F) . East Ave to Jefferson Ave | $96,603 | $46,357 | $263 | $9,252 | $25,900 | 4 | | $10.943 | $6,475 | 2 | $43,771 |
| Short Term | Buffalo Rd(33) - I-490 to Broad St | $116,040 | $36,916 | $416 | $14.671 | $6.475 | t | | $17,353 | $9.713 | 3 | 569.412 |
| Long Term | Buffalo Rd(33) - Rte 259 to I-490 | $104,161 | $35.526 | $373 | $13.136 | $6.475 | 1 | | $15,546 | $6.475 | 2 | $62,160 |
| Short Term | Chill Ave(33A)- I-390 to West Ave(33) | $57,627 | $30.561 | $143 | $5.036 | $19,425 | 3 | | $5.957 | $3.236 | 1 | $23,626 |
| Long Term | Chill Ave(33A)- Rte 259 to I-390 | $174,693 | 964,616 | $563 | $20,529 | $19,425 | 3 | | $24.261 | $12.950 | 4 | $97,125 |
| Medium Term | Clover St(65) . Rte 252 to Rte 31 | $44,677 | $17,611 | $143 | $5.036 | $6.475 | 1 | | $5,957 | $3,236 | 1 | $23,626 |
| Medium Term | Jefferson Rd(96). Thruway to Main St | $166.416 | $56.343 | $563 | $20.529 | $12.950 | 2 | | $24.281 | $12.950 | 4 | $97.125 |
| Short Term | East Ave(96) - I-490/590 to East Maln St | $72,047 | $25.298 | $242 | $6.513 | $6,475 | 1 | | $10.069 | $6,475 | 2 | $40.275 |
| Medium Term | East Ave(96)- Jefferson Rd to I-490/590 | $97.691 | $33.529 | $347 | $12.235 | $6,475 | 1 | | $14.472 | $6,475 | 2 | $57.087 |
| Medium Term | Route 153 - Rte 31F to Rte 96 | $39,160 | $20.273 | $94 | $3.312 | $12,950 | 2 | | $3.917 | $3,236 | 1 | $15,670 |
| Medium Term | Route 250 . Rte 96 to Rte 31 F | $94,464 | $36,657 | $307 | $10.612 | $12.950 | 2 | | $12,766 | $6,475 | 2 | 551.153 |
| Medium Term | Jefferson (252) - W Henrietta to Rte 96 | $160,444 | $61.247 | $537 | $16.914 | $19,425 | 3 | | $22.371 | $9.713 | 3 | $89.485 |
| Long Term | Empire(404) . Rte 590 to Wayne County | $222,202 | $74,442 | $769 | $27.610 | $12,950 | 2 | | $32.893 | $16,186 | 5 | $131.572 |
| Near Term | East Ridge Rd - St Paul IO Bay Shore | $66,299 | $29,637 | $300 | $10.566 | $6.475 | 1 | | $12,497 | $6,475 | 2 | 549.987 |
| | TOTAL | $2.365.324 | $672,966 | $7,679 | $279.850 | $265.475 | 41 | | $319.962 | $166.350 | 52 | $1.324.008 |
| | | Unit Annualized Costs | | $76 | $279,650 | 56,475 | | $2,590 | $3,236 | $3.236 | | $12.950 |
| | | Units | | per mile | per mile | per sign | | per station | per station | per camera | | per mile |
| | | Unlt Capital Costs | | $600 | $2.161.000 | $50.000 | | $20.000 | $25,000 | $25,000 | | $100,000 |

** CCTV NOT Included In the ‘Less Than Fully Instrumented’ calculations
Annualization Factor -10 yrs 0 1 (5% Interest)
On arterlals. CCTV every 2 miles
Delay saved per Incident = 5 minutes
“Less Than Fully Instrumented" Benefits- 50%

*County / Other Site 3 - State Police Headquarters*

The State Police Headquarters is a 4,200 sf. facility in the Town of Henrietta office complex with direct access to Calkins. There is no available space for the TOC in this facility. Access to I-390 is available via Calkins Road to Hylan Drive (approximately 1.5 miles), or via Calkins Road to Middle Road to Lehigh Station Road (approximately 2 miles). The headquarters building is leased by the State Police from the Town of Henrietta. All utilities are available to this building.

*County / Other Site 4 - Rochester City Police*

The Rochester City Police are located in the City of Rochester Public Safety Building. The Public Safety building is a six story masonry building located between Exchange Boulevard and South Plymouth Avenue. Access is available to both streets, with existing ground level and underground parking facilities on site. Occupying all or part of several floors, the city police fully utilize all of their approximately 58,000 s.f of assigned space, leaving none available for the TOC. Located adjacent to the Public Safety Building is the I-490 eastbound on-ramp and westbound off-ramp. The I-490 west bound on-ramp and eastbound off-ramp are within two blocks. This site is located approximately five miles from the MCDOT office and seven miles from the NYSDOT Region 4 office. All utilities are available to this building, including a backup generator.

*County / Other Site 5 - County Sheriffs*

This site is the County Sheriff B - Zone Summit Point office located in the Town of Henrietta. There is no available space for the TOC in this facility. Access to I-390 is available via Lehigh Station Road (approximately 0.75 miles), and access is to the Thruway is available via Lehigh Station Road to I-390 (approximately 1 mile). Alternate access to the freeway system is available via West Henrietta Road. This site is located approximately five miles from the MCDOT office and four miles from the NYSDOT Region 4 office. The County Sheriff leases this property. All utilities are available to this building.

*County / Other Site 6 - Rochester Greater Regional Transit Authority*

This site is the existing Rochester Greater Regional Transit Authority offices. Located in downtown Rochester, the site has direct access to Main Street, with freeway access available via Main Street to the Inner Loop and I-490 via Culver Road. There is no available floor space directly on site, although the potential exists for purchase or lease of adjacent property. All utilities are available on site.

*County / Other Site 7 - City Engineering Bureau*

Located in Rochester City Hall, Building B, on North Fitzhugh Street, the City Engineering Department fully utilizes some 6,000 s.f on the north side of the building. There is no available floor space for the TOC. Rochester City Hall, Building B, is located adjacent to the Inner Loop and several hundred feet southwest of State Street. I-490 is readily accessible via the Inner Loop. The MCDOT office is approximately five miles from the site and the NYSDOT Region 4 office is approximately seven miles from the site. This site is surrounded by offices and small commercial properties. All utilities are available.

*County / Other Site 8 - Monroe County Fire Coordinator*

The Monroe County Fire Coordinator is located in the basement of the Monroe County Health and Social Services Building, adjacent to O.E.P. (County/Other Site 1). This site currently has no space available in which to house the TOC facility. The building and location description are the same as that of the O.E.P.

*County / Other Site 9 - Monroe County Department of Transportation Offices, Iola Campus*

The Monroe County Iola Campus is a multiple building campus which includes engineering offices, a Traffic Control Center, a signal shop, a maintenance shop, an equipment warehouse, a tra fficequipment yard, the Pure Waters Operations Center, the Pure Waters yard, and additional county buildings. Two possible TOC locations exist on the Campus. The first is to merge with and expand the existing Traffic Control Center (TCC). Including operating space, an adjacent area, and a maintenance area, the TCC utilizes approximately 5,900 s.f. Area does exist adjacent to the TCC to construct additional floor space, if necessary. In addition to the TCC, the Iola Campus has approximately twenty available acres, divided into several areas throughout the campus.

## E. Evaluation Procedure

A combined total of twenty-four sites are listed in the three TOC matrices; NYSDOT Properties, New York State Trooper Headquarters, and County / Other Properties. The goal of the evaluation procedure is to reduce the number of sites to the best three or four for an in-depth comparison, which will include site planning, review of property acquisition (if necessary), institutional issues, etc. A three phase process will be utilized to determine the most suitable TOC location. Phase 1 involves the elimination of sites that do not meet a basic set of minimum requirements, Phase 2 utilizes a scoring system to rate the remaining sites, providing a ranking from most to least desirable, and Phase 3 consists of an in-depth analysis of the best sites to determine which site is most suitable for the TOC.

### 1. Phase 1

The purpose of the first phase is to quickly eliminate those sites from further review that do not meet a set of minimum criteria. A list of Building / Site Target Criteria is given which represents the minimum acceptable criteria for the TOC. These criteria represent those attributes a site must have, at a minimum, for successful implementation of the TOC. Sites meeting these criteria are carried forward for ranking in Phase 2.

The following is a list of the minimum criteria.

a) Site Area - 2 acre (87,120 f sq. ft.)

b) Available Parking - 45 to 60 available parking spaces

c) Building Area - 14,000 sq. ft.

d) Building Volume - Ability to have 12' - 0" clearance (min.) within control center (approx. 1,000 sq. A area), 8'-0" to 9'-0" elsewhere

e) Construction Type - Non-combustible/fire protected steel framing or masonry construction.

f) Exterior Windows: Acceptable for office use, minimize for operation center.

g) Floor Loading - 50 PSF (if existing structure to be used)

h) Elevator (if existing multi-floor building to be used)

i) Proximity to major highway corridors - Sites should have direct access to either I-490, I-390 or I-590.

j) Availability to alternate route access and emergency routes.

k) Communication linkage - existing or potential telephone line

1) Utilities - existing or potential for gas, water, electricity, sewer, and storm

All minimums do not readily apply to every site. For example, an undeveloped parcel will not have an elevator. As long as the potential to meet the criteria exists (i.e. an elevator is included in any new facility plans), then the site should be carried forward to the ranking process in Phase 2. Following the same reasoning, if an undeveloped site is unable to connect to an existing sewer line or support it's own system, it would be removed from further consideration.

Phase 1 has been completed for the potential TOC sites. Table VIII-4 lists all sites and states whether they meet the minimum criteria. Once it has been determined that a site does not meet one of the minimum criteria, the site is eliminated. For some categories, the information on the minimum criteria attributes of a site is not readily available. Communication linkage is a prime example of this requirement for additional information. If a site meets all know minimum criteria, it is carried forward to Phase 2 where the remaining minimums will be checked in the more detailed site analysis. Remaining minimum criteria on a site which has already been determined to not meet at least one of the minimum criteria are not checked, since the site is already to be eliminated. As seen in the table VIII-4, ten sites are carried forward to Phase 2.

### 2. Phase 2

Phase 2 in the evaluation procedure involves development of a system by which each site may be ranked. For each site, scores ranging from 1 to 10 are given for each category in the TOC matrix. A weighting system is used to account for the relative importance of each individual category. Overall scores to be used for the ranking of the sites are obtained by summing the weighted scores for each category. The maximum possible overall score is 1,000. The following is the weight and scoring considerations for each category.

1) Ownership - Weight = 10

It is desirable that the TOC building and land be owned by a participating agency. Properties owned by NYSDOT or MCDOT will receive high scores, while properties that must be purchased or leased are given low scores of 5 or less, depending on expected cost and complications of acquisition or leasing.

# CHAPTER VIII

# TRAFFIC OPERATION CENTER EVALUATION

## TABLE OF CONTENTS

### VIII. TRAFFIC OPERATIONS CENTER EVALUATION

# VIII. TRAFFIC OPERATION CENTER EVALUATION

## A. Introduction

This memorandum presents the state of the Rochester Advanced Transportation Management System (ATMS) Traffic Operations Center (TOC) location evaluation process, describing a list of twenty-four potential TOC sites and a three phase process by which the most suitable site alternatives will be selected. Section B of this memorandum discusses the background for this site location evaluation process. Section C describes each of the potential sites and Section D places this site information into matrix form. Section E presents the three phase evaluation process and the results of Phases 1 and 2. Section F summarizes this memorandum.

## B. Background

The Traffic Operations Center will serve as the centerpiece of the Rochester ATMS. Most ATMS functions will be performed at the TOC. Both technically and visually, the TOC will play a major role in defining the success and public image of the Rochester ATMS.

The internal functions of the TOC will include items such as incident management, systems operations, freeway and arterial monitoring, congestion management, and other Intelligent Transportation System (ITS) activities. Important to the success of the internal operations of the TOC is the facilities (i.e. building, grounds, utilities, etc.) and location. Adequate floor space, highway access, communication linkage,' site security, building construction, and alternate route access all contribute to a successful TOC.

This memorandum accounts for the critical nature of the TOC facilities and location, describing a process by which the most suitable location for the TOC may be determined. The following sections of this memorandum list and describe potential sites and review the process by which the final TOC location may be chosen.

## C. Potential Sites

A list of twenty-four potential sites was assembled based upon input from members of city, county, state and private agencies and organizations involved in the Rochester ATMS study. Sites offered were properties owned or controlled by NYSDOT, Monroe County, and other public agencies, and those site under review by the New York State Troopers for their new headquarters location. This list is divided into three site categories; NYSDOT Properties, New York State Troopers potential headquarters locations, and County/Other properties. The following is a list of the sites, along with a brief description of each site (see Figure VIII-l).

## 1. NYSDOT Properties

Nine NYSDOT sites are reviewed as potential locations of the Traffic Operations Center. They include both existing structures and vacant lots. The following provides a brief description of each site.

*NYSDOT Site I - Elmgrove Road and Kodak Access Property*

Located on Route 53 1 between Elmgrove Road and Kodak Access Road, this property consists of a NYSDOT maintenance area, a salt storage building, office trailers, and approximately thirty-two acres of vacant land. This site is bound by, Elmgrove Road in the east, Route 531 in the north, and Kodak Access Road in the west and bordered by the Kodak Elmgrove Site in the south. There is potential for direct access to each of these roads. The site is located approximately three miles from the I-390 / I- 490 interchange, via Route 531, and approximately eleven miles from the NYSDOT Region 4 and MCDOT offices. There is currently overhead electric and telephone service, but apparently no water or sewer service.

*NYSDOT Site 2 - Monroe East Residency*

Located in the Town of Penfield at 938 West Linden Avenue, this site is the NYSDOT Monroe East Residency. NYSDOT Highway Maintenance Monroe East Dispatch currently operates from this location. Further study is required to determine potential space availability. Located in an industrial area, the site has access to Route 441 and Washington Avenue. I-490 access is approximately two miles west via Route 441. I-490 is also accessible via Washington Street and Commercial Street, approximately one mile to the southwest. It is located approximately six miles from the NYSDOT Region 4 office and nine miles from the Monroe County office. All utilities are available.

*MSDOT Site 3 - Lexington Avenue and Ridgeway Avenue Property*

This site is adjacent to I-390, between Lexington Avenue and Ridgeway Avenue. Consisting of an abandoned roadway section of Bellwood Drive, south of the new southbound entrance ramp to I-390, the parcel is slightly less than five acres (approximately 150' x 1400', from R.O.W. to edge of I-390 pavement) with an existing drainage ditch running parallel to I-390 through the center of the site. Approximately one and one half miles to the south is the I-390 / I-490 interchange, and two miles to the north is the Route 390 / Route 104 interchange. Access to Long Pond Road is available

# Rochester ATMS - Traffic Operations Center Evaluation - Phase 2

**Table &III-5**

| Sites \ Criteria (weight) | OWNERSHIP (10) | SPACE AVAILABILITY (20) | HIGHWAY ACCESS (15) | EMERGENCY/ ALTERNATE ACCESS (10) | COSTS (10) | COMMUN. LINK POTENTIAL (25) | SITE ZJTILITIES (5) | SITE SECCJRITY (5) | Score |
|---|---|---|---|---|---|---|---|---|---|
| **Scottsville Site**(1) MC Public Safety Training Facility | 9 | 9 | 9 | 9 | 6 | 9 | 5 | 9 | 850 |
| **County/Other #9** MCDOT lola Campus | 9 | 9 | 8 | 9 | 7 | 9 | 5 | 9 | 845 |
| **NYSDOT #1** Elmgrove Road & Kodak Access | 10 | 10 | 8 | 4 | 4 | 4 | 5 | 7 | 660 |
| **NYSDOT #5** Properties 502 & 655 | 10 | 5 | 8 | 7 | 4 | 5 | 5 | 7 | 615 |
| **NYSDOT #3** Lexington Avenue & Ridgeway Avenue | 10 | 7 | 8 | 4 | 4 | 4 | 5 | 7 | 600 |
| **NYSDOT #6** Property 617 | 10 | 10 | 6 | 3 | 4 | 3 | 4 | 9 | 600 |
| **NYSDOT #9** Property 697 | 10 | 3 | 7 | 7 | 4 | 5 | 5 | 7 | 560 |
| **NYSDOT #2** Monroe East Residency | 10 | 5 | 6 | 2 | 6 | 5 | 5 | 7 | 555 |
| **State Police #3** l-390 | 5 | 5 | 8 | 6 | 2 | 4 | 5 | 8 | 515 |
| **State Police #4** Victory Baptist | 5 | 5 | 6 | 6 | 2 | 4 | 5 | 7 | 480 |

(1) - Scottsville scores based on current site proposals

# ROCHESTER ADVANCED TRAFFIC MANAGEMENT SYSTEM
# POTENTIAL TRAFFIC OPERATION CENTER( OTHER PROPERTIES)

Table VIII-3

| CATEGORIES / SITES | OWNERSHIP | SPACE AVAILABILITY | HIGHWAY ACCESS | EMERGENCY/ ALTERNATE ACCESS | COSTS | COMMUN. LINK POTENTIAL | SITE UTILITIES | SITE SECURITY |
|---|---|---|---|---|---|---|---|---|
| COUNTY/OTHER #1 OFFICE OF EMERG. PREPAREDNESS | Monroe County | None | OS mi to I-390 via W Henrietta Rd. | Via W Henrietta Rd & Westfall Rd. | | O.E.P. link | All available & backup generator | Business area Public building |
| COUNTY/OTHER #2 STATE POLICE - SUBSTATION | Leased | None | 2 mi of north of I-490 via Rte 36 | Rte 33. & Rte 36 | | | All existing to bldg | Center of a small village |
| COUNTY/OTHER #3 STATE POLICE | Town of Henrietta | None | I S MI to I-390 via Calkins & Hylan Rds | Via Calkins Rd. to 15 AN &S | | | Available | Business area |
| COUNTY/OTHER #4 CITY POLICE | See # 1O- Public safety budding | | | | | | | |
| COUNTY/OTHER #5 COUNTY SHERIFF | Leased | None | 0.75 miles to I-390 via Lehigh Station Rd. | Via W. Henrietta Rd. | | | All existing | Remote from city |
| COUNTY/OTHER #6 TRANSIT DISPATCH CENTER | RGRTA | None, Potential for adjacent property acquisition | Via E Main Street, east of Inner Loop, west of 590 | No alternate route to expressway | | Available two communication towers | All available possible backup generator | Mix of residential and commercial properties |
| COUNTY/OTHER #7 CITY ENGINEERING DEPARTMENT | City | None | Rochester Inner Loop | Via State St. to I-490, access E. & W. along Main St. | | Maybe difficult locating antenna due to space constraints. | All available | Surrounded by office bldg. and in city office bldg |
| COUNTY/OTHER #8 CNTY FIRE COOR. | See # 1 OEP | | | | | | | |
| COUNTY/OTHER #9 MCDOT OFFICE | County | -20 Acres or Expand existing 5,900 s.f | 0 25 mi to I-390 via East Henrietta Rd. | Via Westfall Rd. to Wmton Rd to I-590 or to W. Henrietta Rd. to I-390 | | Available | All existing to service bldgs. on site | Remote from residential area, in a large campus |
| COUNTY/OTHER #10 FORMER 911 CENTER | City (Public Safety Building) | 9,300 s.f | I - 490 | Via Court St & S Plymoth Ave to I-490. via Exchange St to S. & N. | | | All available & backup generator | Located in center of city, adjacent county jail |
| COUNTY/OTHER #11 PROPOSED M. C. PUBLIC SAFETY TRAINING FACILITY | City | Proposed Asneeded | I-390 Via Rte 383 | Via Rte. 383 N. to I-490 and City Center, Via Rte. 383 S. to Rte. 252 | | Potential of sharing linkage with MCDOT, O.E.P., etc. | All Proposed | Potential co-location with State and City Police |

# Rochester ATMS - Traffic Operations Center Evaluation - Phase 1

# Table VIII-4

| Sites \ Criteria | Site Area | Available Parking | Building Area | Building Volume | Construction Type | Floor Loading | Elevator | Corridor Proximity | Alternate Route | Communication Linkage | Utilities |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | |
| NYSDOT #1 | Y | Y | NA | NA | NA | NA | NA | Y | Y | MI | MI |
| NYSDOT #2 | MI | MI | MI | NA | NA | NA | NA | Y | Y | MI | Y |
| NYSDOT #3 | Y | Y | NA | NA | NA | NA | NA | Y | Y | MI | Y |
| NYSDOT #4 | — | N | N | — | — | — | — | — | — | — | — |
| NYSDOT #5 | Y | Y | NA | NA | NA | NA | NA | Y | Y | MI | Y |
| NYSDOT #6 | Y | Y | NA | NA | NA | NA | NA | Y | MI | MI | Y |
| NYSDOT #7 | Y | Y | NA | NA | NA | NA | NA | N | — | — | — |
| NYSDOT #8 | N | — | NA | NA | NA | NA | NA | — | — | — | — |
| NYSDOT #9 | Y | Y | NA | NA | NA | NA | NA | Y | Y | MI | Y |
| | | | | | | | | | | | |
| State Police #1 | N | — | — | — | — | — | — | — | — | — | — |
| State Police #2 | N | — | — | — | — | — | — | — | — | — | — |
| State Police #3 | Y | Y | NA | NA | NA | NA | NA | Y | Y | MI | Y |
| State Police #4 | Y | Y | NA | NA | NA | NA | NA | Y | Y | MI | Y |
| | | | | | | | | | | | |
| County/Other #1 | — | — | N | — | — | — | — | — | — | — | — |
| County/Other #2 | — | — | N | — | — | — | — | — | — | — | — |
| County/Other #3 | — | — | N | — | — | — | — | — | — | — | — |
| County/Other #4 | — | — | N | — | — | — | — | — | — | — | — |
| County/Other #5 | — | — | N | — | — | — | — | — | — | — | — |
| County/Other #6 | — | — | N | — | — | — | — | — | — | — | — |
| County/Other #7 | — | — | N | — | — | — | — | — | — | — | — |
| County/Other #8 | — | — | N | — | — | — | — | — | — | — | — |
| County/Other #9 | Y | Y | y(1) | Y | Y | Y | Y | Y | Y | Y/MI | Y |
| County/Other#10 | — | — | N | — | — | — | — | — | — | — | — |
| County/Other #11 | y(2) | y(2) | y(2) | y(2) | y(2) | y(2) | y(2) | y(2) | y(2) | y(2) | y(2) |
| | | | | | | | | | | | |

Y - Meets Minimum Standard
N - Does Not Meet Minimum Standard
NA - Not Applicable
MI - More information needed

— Site Not Meeting Minimum Criteria
(1) - Accounts for possible expansion of existing space
(2) - Assumes minimums may be met by proposed facility

# ROCHESTER ADVANCED TRAFFIC MANAGEMENT SYSTEM POTENTIAL TRAFFIC OPERATION CENTER (NYSDOT PROPERTIES)

**Table VIII- 1**

| CATEGORIES / SITES | OWNERSHIP | SPACE AVAILABILITY | HIGHWAY ACCESS | EMERGENCY/ ALTERNATE ACCESS | COSTS | COMMUN. LINK POTENTIAL | SITE UTILITIES | SITE SECURITY |
|---|---|---|---|---|---|---|---|---|
| NYSDOT #1 RT. 531 BETWEEN ELMGROVE RD. AND KODAK ACCESS RD. | NYS | - 32 Acres | Adjacent Rte 53 1, 3 mi. to I-390/I-490 interchange | Elmgrove Road, Kodak Access Road | | telephone | Elec. overhead, water & sewer expected in 1997 | Remote from residence |
| NYSDOT #2 MONROE E. RESI. 938 W. LINDEN AVE | NYS | | Rte. 441 1 mile to I-490 | Linden Ave., Washington Ave. | | | Available | Fence on 3 sides |
| NYSDOT #3 NY390-BETWEEN LEXING. & RIDGEWAY | NYS | -5 Acres | Rte 390 | Long Pond Rd. via Canal Ponds Office Park | | NYSLINK | Available | Adjoins Retail space in office park |
| NYSDOT #4 REGIONAL OFFICE - 1530 JEFFERSON RD | Lease | Less Than 3000 sf. | Jefferson Rd., Wmton Rd. 1mile to I-390 | No direct access to expressway, Private drive as side street | | No | Available | No barrier |
| NYSDOT #5 NYSDOT PROPERTY: #502,665 | NYS | - 2.5 Acres | I-490 | Via Goodman St. to Monroe Ave., & E. Henrietta Rd. | | No | Available | Light Commercial, Residential Area |
| NYSDOT #6 NYSDOT PROPERTY: 617 | NYS | I7 Acres | I-590, Rte 104 | East Ridge Rd to Rte 104 | | Close to Rochester Telephone's cable line | All available except sewer | Remote from residential area |
| NYSDOT #7 NYSDOT PROPERTY: 628 | NYS | -33 5 Acres | 0.5 mi to Rte 250/ Rte 104 interchange | Orchard Rd to Holt Rd | | Rochester Tel. lines on Rte 250 | Elec & water on Orchard St., CATV, and sewer on Rte 250 | Bordered by light commercial & residential area |
| NYSDOT #8 NYSDOT PROPERTY: #645 | NYS | 1 .8 Acres | Adjacent I-490 | Broadway, Meigs St. Averill Ave. | | Some tall bldgs may interfere radio transmissions | Available | Adjacent to dense residential area, poor |
| NYSDOT #9 NYSDOT PROPERTY: #697 | NYS | 1.9 Acres | Inner Loop @ Joseph Ave., N. Clinton Ave Interchange | Joseph Ave. & Clinton Ave. to City Center | | Possible interference due to surrounding bldgs. | All available | Dense commercial, & close to dense residential area |

Table VIII-2

# ROCHESTER ADVANCED TRAFFIC MANAGEMENT SYSTEM
# POTENTIAL TRAFFIC OPERATION CENTER ( STATE TROOPER HEADQUARTERS)

| CATEGORIES / SITES | OWNERSHIP | SPACE AVAILABILITY | HIGHWAY ACCESS | EMERGENCY/ ALTERNATE ACCESS | COSTS | COMMUN. LINK POTENTIAL | SITE UTILITIES | SITE SECURITY |
|---|---|---|---|---|---|---|---|---|
| STATE POLICE #1 NEXT TO MARINE MIDLAND | Lease | 7,000 SF | I-390 via W Henrietta Rd. | Via W Henrietta Rd | | | Existing | Commercial area |
| STATE POLICE #2 BRYANT & STRATTON BUILDING | Lease | 11,000 SF | 3 mi to I-390/I-590 interchange via. E Henrietta Rd. | Calkins Rd. & Hylan Dr. | | | Existing | Adjacent |
| STATE POLICE #3 HYLAN /I-390 PARCEL | Lease/Buy | 2+ Acres | Adjacent I-390 & Hylan Ave. | Via Hylan Drive | | | Majority along summer sky, limited by I-390 | |
| STATE POLICE #4 VICTORY BAPTIST PARCEL | Lease/Buy | 2+ Acres | I - 390, via E. Henrietta Rd & Jefferson Rd. | Via E Henrietta Rd. | | | | Existing barriers |

must be confirmed. Also, the advantages of co-location with those agencies, given in the description of this property, is not accounted for in the Phase 2 evaluation.

The Iola Campus Monroe County Department of Transportation site is the next highest ranked site. The primary difference between this site and the Training Facility is that the Training Facility has slightly better highway access. Also, this site does not have the multi-agency co-location advantages.

The next six sites are the NYSDOT vacant properties. These sites are all less attractive than the first two sites. All of the sites have a reduced communication link potential and, typically, undesirable highway access. Of these six sites, no one stands out as a much better option than the other five.

The lowest two ranked sites are the State Police sites. These sites were seen to have low communication link potential, limited space availability, and high costs. Of the sites reviewed, these are the least attractive.

### 3. Phase 3

Utilizing the Phase 2 rankings, an in-depth analysis will be performed on the highest ranked sites. Institutional issues, site plans, and public/private issues will all be reviewed to determine which of the highest ranked sites is the most suitable for the TOC. While the highest ranked site has the greatest likelihood of being the most suitable, Phase 3 is necessary to assure that those issues, not easily measurable, that effect the location are taken into account.

## F. Summary

Serving as the centerpiece of the Rochester ATMS, the TOC plays a defining role in determining its success and public image. Critical to the successful operation and utilization of the TOC is the facilities and location. This memorandum presented the state of the TOC site evaluation and selection process. Twenty-four potential sites were listed and described and a three phase evaluation process to determine the most suitable site was presented. The first phase of the evaluation process involves the elimination of potential sites, based on a minimum set of building / site criteria. Phase 2 is a ranking of those sites not eliminated in Phase 1. Phase 3 consists of an in-depth evaluation of the highest ranked sites in Phase 2.

Phase 1 has been completed, as seen in Table VIII-4, resulting in the elimination of all but ten of the original twenty-four sites. The Phase 2 evaluation procedure has also been completed, as shown in Table VIII-5. The Public Safety Training Facility for Monroe County was seen to be the highest ranked, with the Monroe County Iola Campus a close second. These two sites stand out as the most favorable of the reviewed sites. The remaining eight sites are grouped together, with no one site displaying a substantially higher ranking than the other seven.

2) Space Availability - Weight = 20

Space availability, both present and future, is one of the dominating factors and, therefore, receives a high weighting. Space availability consists of two factors, lot size and building size. Lot size is the critical factor on sites were a new TOC building is to be constructed, since adequate space must exist for both the building and parking. On sites where an existing building is to be used, the building size (or expansion potential) is critical, with the lot size becoming critical only in situations were adequate parking is not already available. Sites with the larger lots, building space, and parking facilities, allowing for potential future expansion, receive the higher scores, with the more limited sites receiving lower scores.

3) Highway Access - Weight = 15

Highway access improves the TOC accessibility, site utilization, response times, and visibility. The importance of highway access is only heightened by the potential combination of the TOC with the State Police. Highway access in given a medium weighting since it was part of the Phase 1 evaluation criteria. In Phase 1, all sites have highway access, with the scoring being based more on proximity to major freeway interchanges and quality / congestion of direct access.

4) Emergency / Alternate Access - Weight = 10

Emergency and alternate route access will increase the probability that, during a traffic emergency, TOC staff will be able to reach the center to assist those already on duty. This aids the TOC in avoiding loss of efficiency and usefulness due to staff being delayed or stopped by a traffic emergency; the situation when they are most needed.

5) Costs - Weight = 10

As previously described, the cost category reflects the site preparation costs. That is, the cost of all items necessary to get the site ready for the set up of the TOC. Included within this would be items such as new building construction or existing building renovation, utility connections / installations, property acquisition, etc. As this cost increases, the site's score will decrease. Funding availability for the TOC is readily accounted for in this category by assigning scores based on estimated funding levels required for site preparation.

6) Communication Link Potential - Weight = 25

The communication link potential is one of the most significant elements of the TOC. This category includes proximity to fiber optic networks, microwave towers, and telephone lines, types of telephone lines, cellular phone usage, short range microwave capabilities, etc. Access to these communication networks is vital to the usefulness and success of the TOC.

7) Site Utilities - Weight = 5

Site utilities include items such as electricity, sewer, HVAC, gas, and water. Once Phase 1 minimums have been meet, the utilities will not have a large influence on final site selection. Scoring is a subjective measure of the quality of, and required upgrades to existing utility service.

8) Site Security - Weight = 5

While site security, such as fences and adjacent types of development, is an important part of the TOC, most sites meeting the minimum size requirements in Phase 1 should be able to enhance security, as necessary. Areas considered to have unreasonable security risks should be eliminated in Phase 1.

The Phase 2 evaluation procedure has been completed. The ten sites to successfully meet the Phase 1 minimums were ranked as show on Table VIII-5. Of these ten sites, the Monroe County Public Safety Training Facility and the Monroe County Iola Campus were determined to be the most favorable sites. A complete listing of the site rankings is found in Table VIII-5. Each site is listed, along with its score for each category and its overall score. The sites are arranged in Table VIII-5 from highest overall score to lowest overall score. The weighting for each site is also given on Table VIII-5.

In the Phase 2 ranking, assumptions are made about the Monroe County Public Safety Training Facility space availability and communication link potential. It is assumed that adequate space for the TOC, and necessary communication linkages, such as fiber, may be incorporated into the facility design. Based on our current understanding of the project, these assumptions should be valid. With the Training Facility's high ranking in Phase 2 evaluation, the accuracy of these assumptions will need to be confirmed in Phase 3.

As seen in Table VIII-5, the Monroe County Public Safety Training Facility received the highest overall ranking. This site receives the highest ranking based on those assumptions listed previously. These space availability and communication link potential assumptions

## E. Evaluation Procedure

A combined total of twenty-four sites are listed in the three TOC matrices; NYSDOT Properties, New York State Trooper Headquarters, and County / Other Properties. The goal of the evaluation procedure is to reduce the number of sites to the best three or four for an in-depth comparison, which will include site planning, review of property acquisition (if necessary), institutional issues, etc. A three phase process will be utilized to determine the most suitable TOC location. Phase 1 involves the elimination of sites that do not meet a basic set of minimum requirements, Phase 2 utilizes a scoring system to rate the remaining sites, providing a ranking from most to least desirable, and Phase 3 consists of an in-depth analysis of the best sites to determine which site is most suitable for the TOC.

### 1, Phase 1

The purpose of the first phase is to quickly eliminate those sites from further review that do not meet a set of minimum criteria. A list of Building / Site Target Criteria is given which represents the minimum acceptable criteria for the TOC. These criteria represent those attributes a site must have, at a minimum, for successful implementation of the TOC. Sites meeting these criteria are carried forward for ranking in Phase 2.

The following is a list of the minimum criteria.

a) Site Area - 2 acre (87,120 f sq. ft.)

b) Available Parking - 45 to 60 available parking spaces

c) Building Area - 14,000 sq. A.

d) Building Volume - Ability to have 12’ - 0” clearance (min.) within control center (approx. 1,000 sq. ft area), 8’-0” to 9’-0” elsewhere

e) Construction Type - Non-combustible/fire protected steel framing or masonry construction.

f) Exterior Windows: Acceptable for office use, not desired for operation center.

g) Floor Loading - 50 PSF (if existing structure to be used)

h) Elevator (if existing multi-floor building to be used)

i) Proximity to major highway corridors - Sites should have direct access to either I-490, I-390 or I-590.

j) Availability to alternate route access and emergency routes.

k) Communication linkage - existing or potential telephone line

1) Utilities - existing or potential for gas, water, electricity, sewer, and storm

All minimums do not readily apply to every site. For example, an undeveloped parcel will not have an elevator. As long as the potential to meet the criteria exists (i.e. an elevator is included in any new facility plans), then the site should be carried forward to the ranking process in Phase 2. Following the same reasoning, if an undeveloped site is unable to connect to an existing sewer line or support it's own system, it would be removed from further consideration.

Phase 1 has been completed for the potential TOC sites. Table VIII-4 lists all sites and states whether they meet the minimum criteria. Once it has been determined that a site does not meet one of the minimum criteria, the site is eliminated. For some categories, the information on the minimum criteria attributes of a site is not readily available. Communication linkage is a prime example of this requirement for additional information. If a site meets all know minimum criteria, it is carried forward to Phase 2 where the remaining minimums will be checked in the more detailed site analysis. Remaining minimum criteria on a site which has already been determined to not meet at least one of the minimum criteria are not checked, since the site is already to be eliminated. As seen in the table VIII-4, ten sites are carried forward to Phase 2.

**2. Phase 2**

Phase 2 in the evaluation procedure involves development of a system by which each site may be ranked. For each site, scores ranging from 1 to 10 are given for each category in the TOC matrix. A weighting system is used to account for the relative importance of each individual category. Overall scores to be used for the ranking of the sites are obtained by summing the weighted scores for each category. The maximum possible overall score is 1,000. The following is the weight and scoring considerations for each category.

1) Ownership - Weight = 10

It is desirable that the TOC building and land be owned by a participating agency. Properties owned by NYSDOT or MCDOT will receive high scores, while properties that must be purchased or leased are given low scores of 5 or less, depending on expected cost and complications of acquisition or leasing.

The second possibility is to utilize part of this acreage for the construction of a new free standing building to house the TOC. The Iola Campus is approximately three miles from the NYSDOT Region 4 office. Via East Henrietta Road, it is approximately one quarter mile to the I-390 interchange. Access to the I-590 / Winton Road interchange is approximately three miles, via Westfall Road to Winton Road. All utilities are available to the Campus.

*County/Other Site I0 - Former 911 Center*

This site is the City of Rochester Public Safety building, which also houses the Rochester City Police (County/Other Site 6). The former 911 center was located on the fifth floor of the Public Safety Building, utilizing approximately 9,300 s.f Reassignment of this space has not yet been determined. The building and location description are the same as that of the Rochester City Police.

*County / Other Site 11- Proposed Monroe County Public Safety Training Facility*

The Monroe County Public Safety Training Facility is to be located on Scottsville Road, at the current City of Rochester Police and Fire Academy site. The facility is currently in concept stages with a goal for its design in 1996. Current proposals include the purchase of approximately four additional acres. In emergencies, this site will have representatives from the State Police, County DOT, State DOT, Sheriffs office, Rochester Police Dept., Red **Cross,** Fire Districts, Health Services and Office of Emergency Preparedness.

## D. Traffic Operation Center Matrix

The attributes of the potential TOC sites have been placed into a matrix format. This aids in the evaluation and comparison of the potential TOC sites. Three matrices have been created, one for each category of potential sites; NYSDOT properties, New York State Troopers Headquarters, and County/Other. The matrices contain eight categories which describe the various site attributes. The following is a listing and description of the matrix categories.

| | |
|---|---|
| Ownership | States whether the property is owned or leased. |

| | |
|---|---|
| Space Availability - | Lists amount of space available for the TOC. This is given in square feet for existing structures, and acreage for vacant lots. |
| Highway Access - | Indicates distance to the nearest access to the highway system, i.e. I-390, I-490, I-590. |
| Emergency / Alternate Access - | Lists alternate routes from the site to the highway system. These routes are in addition to those listed in the highway access category. |
| Costs | Reflects approximate site preparation costs. That is, the cost of all items necessary to prepare the site for the installation of the TOC. Included within this would be items such as building construction or renovation, utility connections / installations, communication linkage, property acquisition, etc. |
| Communication Link Potential | This category reflects proximity to fiber optic networks, microwave towers, and telephone lines, types of telephone lines, cellular phone usage, short range microwave capabilities, etc. |
| Site Utilities - | Includes existence or availability of utilities such as electricity, sewer, HVAC, gas, and water. |
| Site Security - | Includes items such as fences, barriers and adjacent types of development. |

Thus far, all matrix site attribute categories have not been completed for every site. Phase 1 of the evaluation process will eliminate many of these sites using a minimum set of standards. Those sites to be eliminated in Phase 1 will not require the in-depth analysis needed to complete several of the matrix categories. For example, the cost category will not be completed for any site until the Phase 1 elimination's have been completed. A potentially time and resource consuming process, the cost category needs only to be a relative measure comparing one site to another in Phase 2, and only fully completed for sites remaining in Phase 3. Phases 1, 2, and 3 of the evaluation procedure are discussed in section E. Tables VIII- 1, VIII-2 and VIII-3 are the TOC matrices.

*County / Other Site 3 - State Police Headquarters*

The State Police Headquarters is a 4,200 s.f. facility in the Town of Henrietta office complex with direct access to Calkins. There is no available space for the TOC in this facility. Access to I-390 is available via Calkins Road to Hylan Drive (approximately 1.5 miles), or via Calkins Road to Middle Road to Lehigh Station Road (approximately 2 miles). The headquarters building is leased by the State Police from the Town of Henrietta. All utilities are available to this building.

*County / Other Site 4 - Rochester City Police*

The Rochester City Police are located in the City of Rochester Public Safety Building. The Public Safety building is a six story masonry building located between Exchange Boulevard and South Plymouth Avenue. Access is available to both streets, with existing ground level and underground parking facilities on site. Occupying all or part of several floors, the city police fully utilize all of their approximately 58,000 s.f of assigned space, leaving none available for the TOC. Located adjacent to the Public Safety Building is the I-490 eastbound on-ramp and westbound off-ramp. The I-490 west bound on-ramp and eastbound off-ramp are within two blocks. This site is located approximately five miles from the MCDOT office and seven miles from the NYSDOT Region 4 office. All utilities are available to this building, including a backup generator.

*County / Other Site 5 - County Sheriff*

This site is the County Sheriff B - Zone Summit Point office located in the Town of Henrietta. There is no available space for the TOC in this facility. Access to I-390 is available via Lehigh Station Road (approximately 0.75 miles), and access is to the Thruway is available via Lehigh Station Road to I-390 (approximately 1 mile). Alternate access to the freeway system is available via West Henrietta Road. This site is located approximately five miles from the MCDOT office and four miles from the NYSDOT Region 4 office. The County Sheriff leases this property. All utilities are available to this building.

*County / Other Site 6 - Rochester Greater Regional Transit Authority*

This site is the existing Rochester Greater Regional Transit Authority offices. Located in downtown Rochester, the site has direct access to Main Street, with freeway access available via Main Street to the Inner Loop and I-490 via Culver Road. There is no available floor space directly on site, although the potential exists for purchase or lease of adjacent property. All utilities are available on site.

*County / Other Site 7 - City Engineering Department*

Located in Rochester City Hall, Building B, on North Fitzhugh Street, the City Engineering Department fully utilizes some 6,000 s.f on the north side of the building. There is no available floor space for the TOC. Rochester City Hall, Building B, is located adjacent to the Inner Loop and several hundred feet southwest of State Street. I-490 is readily accessible via the Inner Loop. The MCDOT office is approximately five miles from the site and the NYSDOT Region 4 office is approximately seven miles from the site. This site is surrounded by offices and small commercial properties. All utilities are available.

*County / Other Site 8 - Monroe County Fire Coordinator*

The Monroe County Fire Coordinator is located in the basement of the Monroe County Health and Social Services Building, adjacent to O.E.P. (County/Other Site 1). This site currently has no space available in which to house the TOC facility. The building and location description are the same as that of the O.E.P.

*County / Other Site 9 - Monroe County Department of Transportation Offices, Iola Campus*

The Monroe County Iola Campus is a multiple building campus which includes engineering offices, a Traffic Control Center, a signal shop, a maintenance shop, an equipment warehouse, a traffic equipment yard, the Pure Waters Operations Center, the Pure Waters yard, and additional county buildings. Two possible TOC locations exist on the Campus. The first is to merge with and expand the existing Traffic Control Center (TCC). Including operating space, an adjacent area, and a maintenance area, the TCC utilizes approximately 5,900 s.f. Area does exist adjacent to the TCC to construct addition floor space, if necessary. In addition to the TCC, the Iola Campus has approximately twenty available acres, divided into several areas throughout the campus.

2. **New York State Troopers Headquarters**

The New York State Police are currently in the process of site review for a new Rochester Headquarters. These site have been included within the TOC site review.

*State Police Site 1 - West Henrietta Road Site*

This site is an existing one story building with approximately 7,000 s.f of available space. Located in a primarily commercial area, one side of the building is adjacent to a Marine Midland bank and the remaining three sides contain parking. The site has direct access to West Henrietta Road, from which I-390 and downtown Rochester may be accessed. This site is approximately three miles from the NYSDOT Region 4 and MCDOT offices. Since this site is not owned by any agencies participating in the TOC, a lease will be required. All utilities are available.

*State Police Site 2 - Bryant and Stratton Building*

Site 2, the Bryant and Stratton Building, has approximately 11,000 s.f. of available space. Direct access is available to East Henrietta Road and Calkins Road. Via East Henrietta Road it is approximately three miles to the I-390 / I-590 interchange. A parking lot is available at this site, with access to additional parking in the adjacent Suburban Plaza. As with State Police Site 1, a lease will be required for this building space. All utilities are available to this site.

*State Police Site 3 - Hylan Drive /I-390 parcel*

This site is a vacant parcel with more than two available acres situated adjacent to major commercial development. Located adjacent to I-390 and Hylan Avenue, this site has ready access to the freeway system. From this parcel, it is approximately three miles to the MCDOT or NYSDOT Region 4 offices. It will be necessary to purchase or lease this parcel if utilized for the TOC. Limited by I-390, the majority of utilities must be drawn from Summer Sky and Hylan drives.

*State Police Site 4 - Victory Baptist Site*

Adjacent to Victory Baptist Church, this site is a vacant parcel with greater than two available acres. Located near I-390, East Henrietta Road, and Jefferson Road, this site has circuitous access to the freeway and arterial street system. This parcel is approximately one mile from the NYSDOT Region 4 office and two miles from the MCDOT offices. As with State Police Site 3, it will be necessary to lease or purchase this property-

### 3. County / Other Properties

Included within these potential TOC sites are properties currently owned by various agencies, other then NYSDOT, that are involved in the Rochester Advanced Transportation Management Systems project. Agencies with sites in this review include: The Office of Emergency Preparedness, New York State Police, Rochester City Police, Monroe County Sheriff, Rochester Greater Regional Transit Authority, Rochester City Engineering Department, Monroe County Fire Coordinator, Monroe County Department of Transportation, and Monroe County Public Safety.

*County / Other Site I - Office of Emergency Preparedness*

County / Other Site 2 - State Police Substation The Office of Emergency Preparedness (O.E.P.) is located in the basement of the Monroe County Health and Social Services Building. Consideration is currently being given to moving the O.E.P. to another location. There is no floor space available in the existing O.E.P. which could be utilized for the TOC. Direct access is provided to Westfall Road, from which West Henrietta Road is accessible. The O.E.P. is less than one half of a mile from the West Henrietta Road / I - 390 interchange, and three miles from the city center. The O.E.P. is adjacent to MCDOT and three miles from NYSDOT Region 4 headquarters. All utilities are available, including a backup generator.

*County / Other Site 2 - State Police Substation*

The State Police substation, located at the intersection of Routes 33 and 36 in the Village of Churchville, is in the same building as a local convenience store. The building is a one story masonry structure with approximately five parking spaces available to the substation. This building is leased by the State Police. The substation floor space is approximately 500 to 1000 s.f., with no space available for the TOC. Approximately one half mile to the north is the I-490 / Route 36 interchange. It is located approximately 20 miles from the NYSDOT Region 4 and MCDOT offices. Located in the center of a small village, the surrounding area consists of small commercial establishments and private residences. All utilities are available to the substation.

through the Canal Ponds Office Park. The parcel is approximately nine miles from the NYSDOT Region 4 office and six miles from MCDOT offices. While the site has no existing utilities, basic utilities are available in an adjoining retail development section of the Canal Ponds Office Park.

*NYSDOT Site 4 - NYSDOT Region 4 Headquarters*

Home to the NYSDOT Region 4 Headquarters, there exists on this site a multi-story building, leased by NYSDOT. There is less than 3000 square feet (sf) of available space in the building, with limited potential for additional floor space construction. Located at 1530 Jefferson Road, the site may be accessed directly only from Jefferson Road. The I-390 / Jefferson Road interchange is approximately one mile to the west, via Jefferson Road, and the I-590 / Winton Road interchange is approximately two miles to the north, via Jefferson Road to Winton Road. It is approximately three miles from the MCDOT offices. All utilities are currently available in the building. An additional consideration for this site is the high utilization of existing parking, which may require additional parking facilities for the TOC.

*NYSDOT Site 5 - NYSDOT Properties 502 and 655*

Included within this site is NYSDOT Properties 502 and 665. Vacant lots totaling approximately two and one half acres (lot 665 at – 1.8 acres and lot 502 at – 0.7 acres), these parcels are adjacent to I-490 and Goodman Street. These properties sit at a higher elevation than I-490 and the same elevation as Goodman Street. A minor roadway, Karges Place, divides the parcels which may require one lot to be utilized for parking and the other for the TOC. These lots are approximately three miles from MCDOT offices and five miles from NYSDOT Region 4 offices. Access to I-490 is available at the Goodman Street interchange, located at the northeast comer of lot 665, and access to the I-390 / I-590 interchange is available via Goodman Street to Mt. Hope Avenue to East Henrietta Road. Alternate access to downtown is provided via Goodman Street to Monroe Avenue. All utilities are available to these properties.

*NYSDOT Site 6 - NYSDOT Property 617*

NYSDOT Property number 6 17 is an approximately 17 acre vacant lot. The parcel is adjacent to the Route 590 / Route 104 interchange and has an existing access road to East Ridge Road. At a distance of less than one half mile, Route 590 may be accessed via East Ridge Road. Approximately one mile from the site is access to Route 104, via East Ridge

Road to Culver Road. The NYSDOT Region 4 office and MCDOT office are both approximately ten miles from the site. While there is no sanitary sewer in the immediate vicinity of the site, there are overhead electric and telephone lines and a water line along the western edge of the site. The adjoining properties include residences to the south and apartments to the north, which are separated from the site by steep slopes and gullies.

*NYSDOT Site 7 - NYSDOT Property 628*

NYSDOT Property number 628 is a vacant lot of approximately thirty-three acres located between Route 250 and Orchard Street, with road frontage on both roadways. The Route 250 / Route 104 interchange is less than one-half mile to the south, and the Route 104 / Holt Road interchange is approximately three-fourths of a mile to the west. This site is located approximately six miles from the Route 104 / Route 590 interchange, and approximately fifteen miles from both the NYSDOT Region 4 and MCDOT offices. The property is partially wooded, and bound by residential areas to the northwest and southeast. Available utilities at the site include telephone and CATV from Route 250, and electric and water from Orchard Street. The property is bordered by light commercial and residential development.

*NYSDOT Site 8 - NYSDOT Property 645*

NYSDOT Property number 645 is a vacant lot bound by Meigs Street, I-490 West, Broadway, and Averill Avenue. The parcel is approximately one and eight- tenths acres. Access is available to I-490 east and west via the South Goodman Street interchange (via Averill Avenue to South Clinton Avenue to South Goodman Street). It is located approximately one mile from the City Police Substation, three miles from the MCDOT office, and five miles from the NYSDOT Region 4 office. Utilities consist of municipal water, sewage disposal, storm sewer, natural gas, electric, and telephone. The fronting streets are paved and lighted. The site is adjacent to dense residential development.

*NYSDOT Site 9 - NYSDOT property 697*

At approximately one and nine-tenths acres, this site is currently a parking lot rented to the City of Rochester. The property is bound by the Inner Loop, Central Avenue, North Clinton Avenue, and Joseph Avenue. Access to I-490 is available via the Inner Loop, and access to the city center is available via Joseph Avenue. This site is approximately five miles from MCDOT office and seven miles from the NYSDOT Region 4 offices. This site is located in a dense commercial area with nearby dense residential development.

# CHAPTER IX

# OPERATIONS PLAN

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## IX. OPERATIONS PLAN

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## A. Introduction

The key to success of the Metropolitan Rochester ATMS will be an effective program of operations and maintenance. This will require personnel located at the Traffic Operations Center (TOC), individuals responsible for field maintenance, and a management structure to coordinate and administer the overall operation. Training of staff, both initially and on a continuing basis as new equipment and functions are added, is critical to insure that the staff can provide maximum effectiveness. Complete and thorough system documentation is also necessary to effective operation. This chapter presents a review of actions and issues related to the operations and implementation of the future system. Procurement methods, staffing, TOC sizing, system start-up plan requirements, and operations plan requirements are addressed.

## B. Agreements and Memorandums of Understanding

In order to be effective, the proposed incident management system must be conceived and operated in a cooperative effort by multiple state and municipal agencies. Generally, its purpose is to be responsive to traffic and incident conditions without regard to jurisdictional boundaries. The system will be designed as a unit, but it must operate in the context of decentralized functions and responsibilities. Since it will support and enhance current functions, the cooperative relationships established for its operation will extend beyond its functions of incident detection, incident response, and motorist information. The system will serve as an effective catalyst to communication among agencies involved in incident response.

A series of agreements and memorandums of understanding will be necessary to establish and support the ATM system. This will need to be developed over a period of time as an ordinary part of system design and development. Multiple agreements or memorandums are advisable in lieu of a single document to provide flexibility for responding to future needs.

Potential needs for cooperative agreements or memorandums of understanding would likely include four categories:

- Agency Support
- System Construction, Operations, and Maintenance
- Emergency Response
- Specialized Control Plans

### 1. Agency Support

One of the first documents to be executed should be a joint statement of support for improved incident management systems and operations within the Metropolitan Rochester area. This should be a statement of policy, with specific roles and responsibilities to be identified in follow-up documents. This agreement should provide a statement of goals and objectives in support of a cooperative policy. The agency support statement should be signed by the state, county and city authorities. This document will serve to inform the public of intent and commitment to the system and will provide general guidance (through goals, objectives, and policies) for further system development.

To best serve its intended purpose, execution of the agency support agreement should be well publicized. This could include format signing ceremonies by county, city and state officials and perhaps include media coverage. In addition to indicating support and cooperation of involved jurisdictions, this will provide an early opportunity for public education regarding the character and intent of the system.

### 2. System Design, Construction, Maintenance, and Operations

Agreements will be necessary among participating jurisdictions and agencies to establish and operate the system. These will be within the categories of funding, system operation and maintenance, and functional roles and responsibilities. Among the topics which may need to be addressed are the following:

- Funding

  - engineering
  - construction
  - start-up
  - operations

- System Operation and Maintenance

  - control center
  - field equipment
  - administration and management
  - staffing

- Functional Roles and Responsibilities

    - communication responsibilities of traffic control center
    - on site coordination (incident manager, call for tow trucks, etc.)
    - role and limitations of service patrols
    - identification and management of diversion route systems
    - operation of variable message signs and motorist information systems
    - data links (CCTV, traffic counts, operating speeds, etc.)

**3. Emergency Response**

Agreements, legislation, and cooperative understandings are already in place for the coordination of incident response as part of the existing all center operations. Changes may occur as emergency response personnel interact within the incident management committee and as the system design evolves but the system will not supplant or modify most established relationships. Some potential new emergency response policies may require enabling legislation, including:

- Vehicle removal policies
- Lane closure policies
- Tow truck notification policies

**4. Specialized Control Plans**

In addition to agreements and/or memorandums of understanding for day-to-day system operations and emergency response, it may be useful to establish roles, responsibilities, and relationships for special conditions. These include the following, as a minimum:

- Recurring special events
- Unique special events
- Maintenance of traffic during construction
- Special incidents, such as HAZMAT spills

**C. Hours of Operation**

Experience from other freeway management systems show that the TOC needs to be ataffed from the beginning of the morning rush hour to the end of the evening rush hour, typically from 6 AM to 7 PM. For ease of initial operations it is suggested that **15** hours (generally 5:30 am to 8:30 pm) with a one hour shift overlap be used. Weekend staffing may not occur initially but eventually it should go from 9 AM to 5 PM, especially during special events or adverse weather. Taking into account vacations, sick leave, training time, and other activities, this translates into 3 full-time equivalents for the operations staff to provide one operator at the system console during these hours. This would be overseen by at least one systems manager and a control room operations supervisor.

Two different strategies for providing staff have been utilized by different agencies: utilizing agency personnel (either existing or new hires), and contracting to a private organization to provide the personnel. (This is the case for the INFORM System on Long Island.) In either case, the budgetary impact is essentially identical, although the specific budgetary categories may be different. As such, there is no distinction as to which approach is used.

During mid-day hours, when traffic is lighter, the operational staff can utilize some of their time to perform other activities that can be handled from within the control room. But the operator is still required to be immediately available to monitor and coordinate response to an incident which might occur. During the hours when the control room is not staffed, i.e., at night and on weekends, the system design and architecture must allow an auxiliary console to be located at a 24 hours per day facility, such as the EMS or police dispatch center.

**D. Traffic Operations Center Operators**

The specific functions that the operator needs to perform include:

- Utilizing the computer displays and CCTV screens to monitor and verify the traffic conditions and incidents on the freeways;
- Operating the computer systems, through a keyboard or mouse or joystick, to select different displays and to control field devices, such as Variable Message Signs and CCTV cameras;
- Responding to status and alarm messages from the computer systems, again with a keyboard and mouse, that are generated when incidents are detected or a equipment malfunctions are detected;
- Utilizing telephone and radio equipment to communicate with police, incident response personnel, fire personnel, etc. who are responding to an incident;
- Utilizing telephone or FAX equipment to communicate with media and the public regarding the status of an incident or current traffic conditions;
- Operating recording equipment, such as a VCR that would be utilized to capture the specifics of a particular incident;
- Troubleshoot and perform simple replacements for malfunctioning equipment in the TOC;
- Maintaining logs and other required records of activities.

Several different strategies have been utilized by other TOCs for hiring operators. These include college students working part-time, disabled individuals on either a part-time or full-time basis, or till-time agency technical or support staff.

## E. Equipment Maintenance

The maintenance and repair of all equipment must be accomplished in a timely fashion in order to achieve effective system operation. The typical goal for these systems is a four hour response fro, the time a failure is reported until the equipment is returned to service. This requires a maintenance technician with adequate spares, appropriate tools and equipment, and up-to-date training.

For the scope of the initial ATMS project, one maintenance technician will be adequate. While it is possible to share this individual with other maintenance and support activities, it is important that the technician's first priority be the support of the field equipment, and not arterial signals or equipment of another organization. This individual should be available prior to the start of any construction for the project so that familiarity with the system design can be obtained. The technician's input to the design process, to insure that maintainability is built into the system, will yield long-term benefits. The technician should serve as the field inspector during all construction work so that details are retained by an agency employee. Also, since the technician will have to live with or correct any problems created by the construction, there will be a strong incentive to get the system built correctly.

Another important role of the maintenance technician is to coordinate with other roadway maintenance or construction activities to minimize the disruption of field equipment. Because contractors and other organizations do not recognize the importance of the field equipment and associate power and communications circuits, their inadvert actions can create problems. The maintenance technician, by being available or on-site during these potential disruptions, can minimize or eliminate equipment down-time.

The maintenance technician needs to be well experienced in a wide range of skills, including electronics, communications, power distribution, cable installation and repair, portable generators, and general small scale mechanical repairs. Since the maintenance technician will be faced with a diversity of equipment and failure conditions, a broad set of general repair capabilities is required. Effective troubleshooting and problem isolation techniques, supported by a systematic and logical approach, is needed to quickly identify and correct problems. Preventive maintenance, locating and repairing small problems before they become major, and conscientious record keeping and documentation are also regular components of the equipment maintenance program.

## F. Operations and Maintenance Costs

Adequate performance of the equipment tasks for routine, daily operations will generally require personnel in administrative, operations, and maintenance classifications. Of paramount importance in considering overall staff requirements, is the obtainment of a certain level of redundancy in personnel in the operations and maintenance classifications to insure that the random occurrence of simultaneous, multiple events and/or incidents will not adversely affect overall system performance and personnel response.

The staff requirements and costs to achieve this goal are presented as a general basis of defining overall space needs. Daily weekday operations consisting of approximately 15 to 16 hours per day. Approximate hours of operation are anticipated to be 5:30 AM to 8:30 PM to provide adequate coverage for both AM and PM peaks, with allowances for "late clearing" of PM congestion and some overlap of shifts.

Staff Assignments and schedules are shown in Table IX-l.

Table IX- 1
Traffic Operations Center Staffing and Schedule
Primary Routes

| Staff | Number | | Schedule |
|---|---|---|---|
| | Short/Medium-Term | Long-Term | |
| **Operations** | | | |
| Systems Manager | 1 | 1 | 8:00AM - 5:00PM |
| Asst. Systems Mngr. /Shift Supervisor | 1 | 1 | 6:00AM - 3:00PM |
| Control Room Supervisor | 0 | 1 | 11:30AM - 8:30PM |
| Control Room Operators | 1 | 2 | 5:00A.M - 2:00PM |
| Control Room Operators | 1 | 2 | 12:00PM - 9:00PM |
| **Maintenance** | | | |
| Maintenance Supervisor | 1 | 1 | 8:00AM - 5:00PM |
| Asst. Maintenance Supervisor | 0 | 1 | 9:00AM - 6:00PM |
| Electronics Tech. | 2 | 4 | 6:30AM - 3:30PM / 9:30AM - 6:30PM |

Table IX-2 summarizes the subtotal annual operations and maintenance costs in 1995 dollars for the implementation of each phase.

The annual operations, maintenance and equipment parts/physical plant in the following table represents the total annual costs at the end of each of the phases. For example, the costs of Operations Staff at the Short-Term phase also includes the cost of Operations Staff of the Near-Term. The costs of Operations Staff at the Medium-Term phase includes the Near, Short and Medium-Term Operation Staff costs.

Table IX-2
Annual O& M Cost Summary
Primary Route System

| Phase | Operations staff | Maintenance Staff | Equipment Parts/ Physical Plant | Total Annual O&M |
|---|---|---|---|---|
| Near-Term | $60,000 | $50,000 | $40,000 | $150,000 |
| Short-Term | $305,000 | $109,000 | $523,000 | $1,018,000 |
| Medium-Term | $305,000 | $190,000 | $1,103,000 | $1,598,000 |
| Long-Term | $475,000 | $365,000 | $1,198,000 | $2,038,000 |

## G. System Management

A manager of the operators and maintenance technician will be required. It is desirable that this individual also have an engineering background so that broader system support and long-range upgrades can be handled. The role of the manager is to provide day-to-day supervision and scheduling of operations and maintenance activities, to coordinate with other agencies and organizations, to develop plans and policies for incident management and freeway monitoring, and to financially manage the operation by developing budgets and being responsible for operating within these budgets.

The manager will also be available to support the operator during a major incident, to provide higher level liaison with other agencies and the media, and to serve as a back-up person if regular operations personnel are not available. The manager will be responsible for training new operations personnel, and insuring that current staff are trained on new equipment and that refresher training is conducted for all personnel.

The manager will be responsible for supervision of maintenance activities, insuring that adequate spares are available and that the maintenance technician has all the tools, equipment, and test devices needed to perform effectively. The manager must make certain that the technician's training is current and up-to-date. When a crises occurs, the manager must serve as an expediter for factory support and repair services, and provide a buffer between the maintenance technician and other individuals, so that the technician can work without being disturbed. When the maintenance technician is on vacation, sick-leave, at training, etc., the manager must be able to fill-in and provide basic levels of equipment support and repair.

Support staff, such as secretarial, clerical and receptionist personnel, can be provided on a shared basis fi-om the existing organization where the TOC will be located. The requirements of the ATMS are not such that dedicated personnel are needed. A part-time equivalent is included in the budget to account for this labor component.

## H. Procurement Methods

An important element in the implementation of the Rochester ATMS is the method to be used for procurement. Several procurement techniques have been used throughout the country on related projects. These are outlined below:

### l. Sole Source

The basis for a sole source procurement is the documented existence of only one technical or cost-effective solution to the requirements of a particular project. The most common basis for sole-source procurements are the requirements for compatibility with existing equipment, so that system-wide interoperability can be maintained. For an initial systemwide procurement, compatibility with existing equipment is not a factor, and sole-source procurement is not advisable or practical.

For later project phases, sole-source procurements will probably be necessary to maintain equipment compatibility for specific devices, such as CCTV camera controllers. Operating and maintenance problems caused by incompatible equipment are design and procurement issues for the initial system. Conversion or replacement of non-interoperable devices before the end of their useful life is an expensive penalty to be paid for lack of foresight.

### 2. Engineering / Contractor

This procurement method is the one typically used for highway projects. It is based on the concept that all critical system parameters can be fully specified and documented in a single set of contract documents (i.e., Plans, Specifications, and Estimates - PS & E package), that a single contractor is best suited to implement the project, and that the only criteria of significance for selecting the contractor is the initial bid price. The extensive experience with this process for highway construction has resulted in a very rapid set of procedures and rules within most highway agencies, severely restricting the flexibility of system designers and implementers.

### 3. Two-Step Approach

This method modifies the engineer/contractor technique by separating the technical evaluation step from the financial step. This approach provides an opportunity to reject proposals that do not meet the technical criteria for the project. This minimizes the risk of selecting a contractor whose bid is low, but who is not technically capable of performing the work. It also insures that the technical merits of each proposal are fully considered prior to award of a contract, instead of during the "material submittal" stage of a traditional highway construction contract.

### 4. Design / Build

In this approach, a single entity is selected to handle all the work associated with implementing the system. The design / builder is responsible for detail system design, procurement of all equipment, construction of all system elements, integration of the various sub-systems, and final system turn-up and operational cut-over. The fully functional system is then turned over to the operating agency. A design/build concept simplifies the number of contracts and the steps associated with taking a system from concept to operations. This can be beneficial if the designer/builder fully understands the project concept, and has the experience to successfully handle the full scope. Often the design/builder can use streamline equipment purchase procedures, thereby speeding up the project schedule.

However, this approach limits the agency's role to that of limited oversight and monitoring activities of the design/builder. This can be detrimental since the agency personnel with direct operational experience and needs are typically not involved with the detail design and thus cannot provide input and feedback during design and implementation.

### 5. System Manager/System Integrator

This procurement method divides the project into several sub-projects for each of the various sub-systems, with the work overseen by a system manager who administers each contract and is responsible for integrating the several sub-systems into an overall, operating system. The most effective structure for this approach is to use a moderate sized "design team" consisting of agency and system manager personnel. The system manager converts the project plan into preliminary designs and defines sub-systems, develops PS&E packages for sub-systems, oversees bidding and award, supervises construction, selects and procures computer and communications hardware components, develops system software, integrates and tests sub-systems, and supervises operator training.

By assigning responsibility for total system success to the system manager, a single source of accountability and responsibility is defined. The involvement of agency personnel as part of the design team results in improved coordination and tighter cost controls. The agreement between the agency and the system manager is a negotiated contract, which can be easily adapted as project needs are refined. This provides increased flexibility to meet the specific project requirements, when compared to the typical fixed price turnkey or design/build contracts.

## I. Implementation

Part 655.409 of Title 23 Code of Federal Regulations requires the development of an Implementation Plan prior to the deployment of surveillance and control elements of an incident management plan. According to current guidelines, the Implementation Plan is to be completed prior to project design completion and must be approved by FHWA prior to authorization of construction funding. The Implementation Plan will need to finalize needed legislation, system design procurement methods, construction management procedures, acceptance testing, and system start-up. It will also need to include an operation and maintenance plan which is specific to the equipment to be installed. The intent of the Operations Plan will be to clearly describe all significant system features and the means for installing and operating the system. An important element of the Operations Plan is the commitment of involved agencies to staff the system and fund its operation. Many of these issues must await design activities in order to provide an appropriate level of detail.

## J. Traffic Operations Center Concept

Three generic conceptual plans for a Traffic Operations Center are presented on Figures 1X-1, IX-2, and 1X-3. The three plans range in total area from 4,000 SF to 10,000 SF. These layouts assume that the traffic operations center is co-located with other functions in a single facility. Functions that are assumed to be located elsewhere in the facility include:

- Emergency generator, load bank, and fuel tank
- Transformers, main building electrical room
- Building HVAC equipment
- Condenser, radiator or chiller for computer/communications room air handling units
- Restrooms
- Employee lounge or lunchroom
- Main reception area
- Multi-purpose space
- Conference room and clerical support (except in 10,000 SF scheme)

The 4,000 SF scheme (Figure IX-l) has space allocations below the minimum range of estimated space needs. Its control room has positions for four traffic controllers. This layout assumes that air distribution and cable routing are accommodated without raised access flooring. The opening office cubicles in the staff area are sized at 7.5 feet by 7.5 feet. No provision is made for as yet undefined items such as file cabinets, book cases, printers, plotters, copiers or fax machines.

The 7,000 SF scheme (Figure IX-2) has areas generally within the range of expected space needs. Its control room has space for up to five or six traffic operations and/or communications positions. No provision is made for rear projection video although with emerging flat display technology, this may not be an issue. The viewing, operations and electronics areas are on raised access floor. The staff area has space for 12 people in open office cubicles plus a shared equipment or drafting station. Lateral files or bookcases line the circulation spine. A small copy/supply room is shown, but may not be needed depending on proximity of similar functions elsewhere in the facility. This scheme is laid out with a general building circulation corridor bisecting the TOC.

The 10,000 SF scheme (Figure 1X-3) approximates an upper range of potential space needs. It illustrates a control room subdivided into operations and communications. Space is provided for up to six traffic operations positions and two communications positions. Room for one large screen, rear projection video display is included. The control room and electronics room are on raised access floor for cooled air supply and cable distribution. Offices and staff areas are laid out for up to 25 percent growth; i.e., one additional office and three additional staff cubicles.

All of these schemes are generic in nature. No provisions have been made for accommodating specific facility requirements such as configuration of space available, building circulation patterns and exiting requirements, exterior windows, views, and glare, adjacencies of other building functions, or building structural, mechanical and electrical systems. Generally an overall building size of between 15,000 and 20,000 SF would be developed for this type of operations.